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THE CARE OF THORACIC AND THORACOABDOMINAL WOUNDS IN THE COMBAT ZONE IN KOREA

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THIS study is based on 163 thoracic and thoracoabdominal injuries handled at the Mobile Army Surgical Hospital 8076 Army Unit in Korea between July 17, and Dec. 17, 1951.

The missile wounds were penetrating in 126 cases (77.3 per cent), perforating in 32 cases (19.6 per cent), and the remaining 5 cases (3.1 per cent) had crush injuries of the chest. One hundred and twenty-seven (77.9 per cent) of these patients had thoracic and 36 (22.1 per cent) had thoracoabdominal injuries. The wounds were sucking at the time of admission or during the process of débridement in 43 cases (26.4 per cent). The pathology was unilateral in 152 (93.3 per cent) and bilateral in 11 (6.7 per cent) of the patients. Of the 152 unilateral injuries 86 (57 per cent) were located on the right and 66 (43 per cent) on the left side.

PREOPERATIVE CARE

At the time of admission the wounds were carefully surveyed. Physical examination, posteroanterior and lateral x-ray views of the chest were utilized in the evaluation of the patient. Blood pressure, pulse, and the rate of respiration were checked at frequent intervals. Blood transfusion was started without delay unless there was no definite evidence of appreciable blood loss. All the patients were given antibiotics, namely, one million units of crystallin penicillin and 1 Gm. of streptomycin at the time of admission followed by 600,000 units of penicillin every six hours and ½ Gm. of streptomycin twice a day during their stay in the hospital. The patients were kept in a position most comfort-

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This study was made at the Mobile Army Surgical Hospital 8076 Army Unit, North Korea. The statements and conclusions published by the author are the result of his own study and do not necessarily reflect the opinions of the Medical Corps, United States Army.

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able to them which frequently was Fowler or semi-Fowler. Those in shock were kept flat on their backs or in the Trendelenburg position. Oxygen was administered as indicated through nasal catheters.

CLINICAL MATERIAL

Table I is a summary of the clinical material and indicates the type of pathology represented, and the form of therapy applied with the results.

TABLE I. A SUMMARY OF THE CLINICAL MATERIAL

FINDINGS	PENETRATING WOUNDS	PERFORATING WOUNDS	CRUSH INJURIES	EVACUATED	DIED	TOTAL
Retained metallic foreign bodies without hematoma, hemothorax or pneumothorax	15			15		15
Hematoma	9	3		12		12
Hemothorax, hemopneumothorax or pneumothorax treated by repeated aspirations	38	7		45		45
Crush injuries			5	5		5
Sucking wounds of the chest treated by tube aspiration and closure of the wound	13	9		22		22
Conditions requiring thoracotomy or its modifications	11	6		14	3	17
Thoracoabdominal injuries submitted to laparotomy and suction through the diaphragm	17	2		16	3	19
Suspected thoracoabdominal injuries with negative laparotomy findings	10	1		8	3	11
Conditions requiring thoracoabdominal exploration	9	4		10	3	13
Independent chest and independent intra-abdominal injuries	4			4		4
Totals	126	32	5	151	12	163

I. THORACIC INJURIES

Some of the penetrating missile wounds of the chest required no other treatment than débridement of the entrance wound or wounds. They were the ones with the metallic foreign body retained in the lung without evidence of hematoma, hemothorax, or hemopneumothorax on x-ray pictures. Clinically these patients were asymptomatic. They were kept under observation for two or three days prior to their evacuation. There were fifteen such cases in this series.

Twelve of the patients had no other symptoms than hemoptysis and at times pain on the side of the injury. X-ray pictures of the chest showed one or more well-defined areas of density within the parenchyma without evidence of hemothorax or hemopneumothorax. The wounds were débrided, the tracheo-

bronchial tree was kept free by encouraging coughing and expectoration, and, if needed, by bronchial catheterization or bronchoscopic suction. The hematoma of the lung in these cases cleared or regressed to a great extent prior to evacuation within three to seven days.

Forty-five of the penetrating and perforating missile wounds which led to hemothorax or hemopneumothorax were submitted only to débridement of the wounds and repeated aspiration of air and/or blood from the pleural space. The aspirations were performed as soon as the evaluation of the case was completed. As much as 1,000 c.c. of blood was aspirated at one time in many of the cases, and, if x-ray pictures showed evidence of reaccumulation of blood, the aspiration was repeated daily or, if necessary, even on the same day. Prior to the removal of the aspirating needle ½ Gm. of streptomycin and 400,000 units of penicillin were instilled into the pleural space following each aspiration. The patients with hemopneumothorax or pneumothorax were submitted also to deflation of the pleural space. This was accomplished by the application of suction (by an electric suction machine) to the aspirating needle. The suction at times was continued as long as fifteen minutes. These patients showed evidence of good lung re-expansion. The clouding caused by the hemothorax cleared completely, or to a great extent, prior to evacuation within two to eight days with the exception of two patients. In these two cases the need for surgical evacuation of clotted, or perhaps organized, blood from the pleural space was obvious.

Five patients were seen with crush injuries represented by multiple rib fractures, hemothorax, and hematoma of the lung. Intercostal nerve block with 1 per cent procaine, repeated aspiration of the hemothorax, and keeping the air passages clear by repeated catheter aspirations stabilized these patients. They all were evacuated in good condition and their lungs expanded within three to eight days following admission.

The open or sucking wounds of the chest, or wounds suspected of being such, with hemothorax or hemopneumothorax were handled under general endotracheal anesthesia. The wounds were débrided, a thoracotomy tube was inserted through the débrided wound, and the pleural space was aspirated. The wound was closed up to skin level while the lung was kept inflated and the temporarily inserted thoracotomy tube was removed simultaneously. As indicated by subsequent x-ray findings some of these patients needed further daily needle aspiration. Those sucking wounds which presented evidence of depressed rib fractures required resection of the irregular rib ends. In these cases the pleural space was irrigated with normal saline solution prior to the closure of the chest wall defect by approximation of the soft tissue layers outside of the parietal pleura. Also, a thoracotomy tube was inserted into the pleural space in a dependent position for continuous underwater drainage. Twenty-two of the forty-three sucking wounds of the chest were treated only by this method resulting in fully re-expanded lungs with only evidence of clearing parenchymal clouding at the time of their evacuation. The rest of the sucking wounds fell into the group of thoracoabdominal injuries.

Conditions requiring open thoracotomy or modifications of it at a Mobile Army Surgical Hospital level are few: (1) active intrapleural bleeding from injured lung with or without internal mammary or intercostal vessel injury; (2) injury of mediastinal structures; (3) presence of large intrapleural metallic foreign body, if it is easily accessible from the site of the entrance wound; (4) wounds of the large bronchi and intrathoracic part of the trachea; (5) wounds of the heart.

Contrary to the writings of Mackler,[1] Tuckwell,[2] Woodruff,[3] Blackburn,[4] and others, perforation or anatomic likelihood of perforation of the diaphragm was not found to be an indication for open thoracotomy.

A total of seventeen patients were submitted to open thoracotomies. Three of them died in the operating room: one, of perforation of the aorta; two, of heart wounds. The cardiorespiratory function of the two patients with heart wounds ceased before the incisions were made and the thoracotomies were performed primarily for purposes of resuscitation. The remaining fourteen patients were evacuated in good condition with the lung well expanded and aerated, showing evidence of parenchymal clouding only at the site of the repaired lung wounds. In four of them the chest was entered through extensions of the chest wall wound. The remaining thirteen patients were operated on through elective incisions. In four of the patients a posterolateral approach was used, and in nine of them the chest was entered through anterior incisions (Diagram 1, *A*, *B*, *C*, and *D*). In this procedure the pleural cavity was entered through the third, fourth, or fifth anterior intercostal space, and correspondingly the third and fourth, or fourth and fifth, or fifth and sixth cartilages were divided. The skin incisions were placed over the intercostal space which was to be utilized as an entrance to the pleural cavity, and were extended from a point about one inch medial to the costochondral junction to the midaxillary line. If the plan was to divide more than two cartilages the incision was extended downward at a right angle to its medial end (Diagram 1, *B*, *C*, and *D*). A meticulous closure of the wound in layers assured good healing. The lung lacerations were carefully débrided and the bleeding points controlled by suture ligatures of 00 or 000 silk. The bronchial openings were closed with 00 silk mattress sutures. The débrided lung surfaces were approximated in layers with 00 chromic catgut sutures. The perforating wounds of the lung were handled in a similar fashion except that in the tunnel of the wound strips of Gelfoam were inserted. Only nonviable subsegments or segments of the lung were resected. In none of the cases was lobectomy or pneumonectomy performed. Prior to the closure of the chest wall the pleural space was carefully irrigated with normal saline solution, the lung was fully re-expanded, and two thoracotomy tubes were inserted into the pleural space for underwater drainage.

II. THORACOABDOMINAL INJURIES

As stated previously perforation of the diaphragm is not an indication for open thoracotomy. These thoracoabdominal injuries were handled by laparotomy preceded by closure of the sucking wound of the chest, if such existed. The diaphragmatic perforation was closed from the abdominal side

while the contents of the pleural space were aspirated by a thoracotomy tube which was inserted into the pleural space through the tear of the diaphragm. The tube, to which constant suction was applied, was removed while the last stitch of the diaphragm was tied and the lung kept inflated, simultaneously. In cases where a hollow viscus of the abdomen was perforated, the pleural space was carefully irrigated with saline solution prior to the closure of the diaphragmatic tear; frequently a thoracotomy tube was inserted into the pleural space, usually after the completion of the laparotomy.

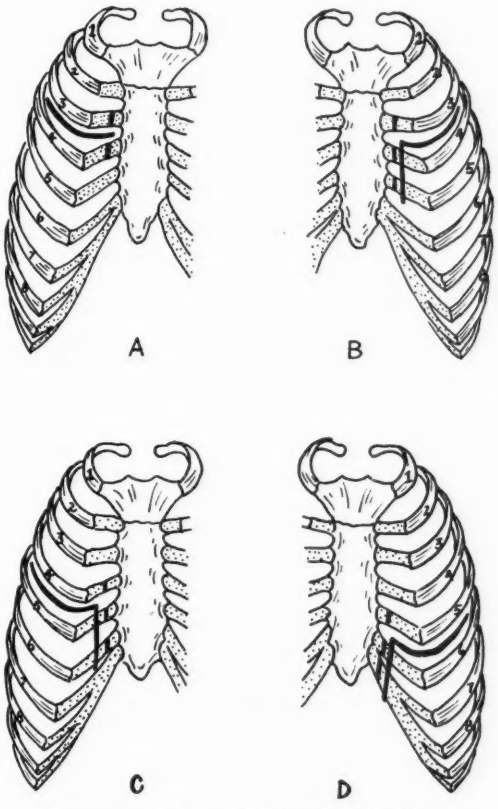


Diagram 1.—Varieties of thoracotomy incisions.

Nineteen of our patients were handled in this fashion. Sixteen of them were evacuated in good condition with the lung well expanded within ten days, following their operation. Three of the patients died: one in the operating room of shock; one, two days following the operation, of irreversible shock and renal shut down; and one, six days following the operation, of adynamic ileus and renal shut down.

There were eleven suspected thoracoabdominal injuries which were subjected to laparotomy with negative intra-abdominal findings. If the abdominal findings were unilateral, intercostal nerve block served as a great help in differentiating referred thoracic signs and symptoms from true abdominal pathology. Eight of these patients were evacuated in good condition with the injured lung well expanded. Three of them with bilateral chest wounds died. Each of these patients had sucking wounds which were taken care of prior to laparotomy. All three of them died of respiratory failure caused by extensive bilateral intrapulmonary hemorrhages. In each case x-ray examination showed well-defined areas of clouding of both lung fields. The patients expectorated considerable amounts of blood. Two of them died on the first, and one on the second, postoperative day. Two of these patients were autopsied confirming the clinical and x-ray findings of extensive bilateral pulmonary hepatization.

Conditions requiring thoracoabdominal exploration or modifications of it are few. These are upper abdominal and lower thoracic injuries not accessible through laparotomy wounds alone such as:

(1) some of the liver wounds; (2) few of the otherwise not accessible diaphragmatic tears; (3) injuries of the lower end of the esophagus and cardiac end of the stomach.

These conditions, of course, are in addition to the cases with indications for open thoracotomy which also have evidence of intra-abdominal injury.

Thirteen patients were in this group of which only eight were true thoracoabdominal explorations. Three of them were submitted to thoracotomy followed by laparotomy. Two of them had laparotomies and débridement of chest wall defect leading to adequate exposure to correct the intrathoracic part of the pathology. Ten of the patients did well and were evacuated with well-expanded lungs, showing x-ray evidence of hematoma only at the site of the repaired lung injury. Three of them died: two in the operating room of cardiac standstill, and one of adynamic ileus on the seventh postoperative day.

The operative approaches to abdominothoracic exploration are indicated in Diagram 2, *A*, *B*, *C*, and *D*. A midrectus, or occasionally a paramedian laparotomy incision was always used. After the abdominal cavity was opened and the indication to enter the chest was established, the operative incision was extended upward through the seventh, sixth, and fifth cartilages, and at times even the fourth. If needed, a lateral extension was made to the midaxillary line within the intercostal space below the highest divided cartilage (most commonly the fifth). In the majority of the cases this lateral extension of the incision was not necessary (Diagram 2, *D*). At times, the diaphragm was divided up to the tear or perforation in order to increase the visibility posteriorly. In cases of urgency in the thoracic part of the injury, as in cases of active bleeding, the operation can be started as an anterior thoracotomy and later the incision extended downward.

Independent chest injuries with independent abdominal injuries resulting from multiple penetrating shell fragment wounds were handled as indicated. The principle of early re-establishment of normal cardiorespiratory physiology in so far as possible was kept in mind. The chest injuries were first treated

thus increasing the chances that these patients would survive a subsequent immediate laparotomy. Four patients were handled in this manner. All of them were evacuated in good condition with the injured lung fully expanded.

POSTOPERATIVE CARE

In the postoperative period the antibiotic therapy was maintained until the evacuation of the patients, which was approximately ten days. The thoracotomy tubes were frequently suctioned, in addition to the continuous underwater drainage. Breathing exercises and coughing were encouraged. Bronchial catheterization and bronchoscopic suction were applied without hesitation. Needle aspirations were performed if the x-ray findings suggested reaccumulation of intrapleural fluid.

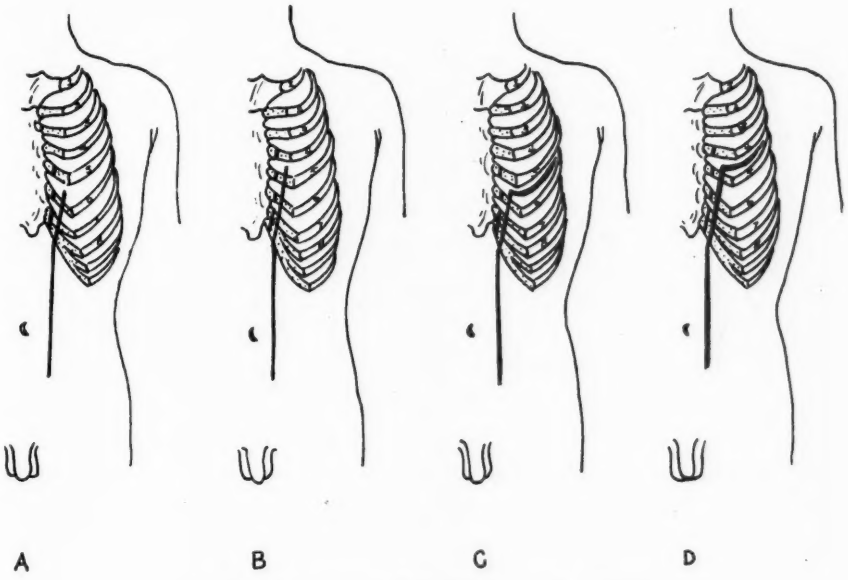


Diagram 2.—Varieties of abdominothoracic incisions.

ILLUSTRATIVE CASES

CASE 1.—F. R., an American corporal, sustained multiple shell fragment wounds of the face, neck, and chest. One metallic foreign body was retained in the anterior chest wall and one in the right hilar region. Posteroanterior and lateral x-ray views (Figs. 1 and 2) of the chest failed to reveal hemothorax, pneumothorax, or evidence of intrapulmonary bleeding. Follow-up x-ray pictures in two days, prior to evacuation, showed no change in the appearance of the lung. This patient required no active therapy other than débridement of the wounds and antibiotics.

This is a representative case of penetrating missile wounds without destructive consequences.

CASE 2.—E. T., an American corporal, sustained crush injury to the right chest in a truck accident. He had moderate subcutaneous emphysema. X-ray pictures showed fracture of the first to seventh ribs inclusive on the right side and evidence of minimal hemothorax. Intercostal nerve block with 1 per cent procaine was done from the first to the ninth inter-

Fig. 1. Fig. 2.

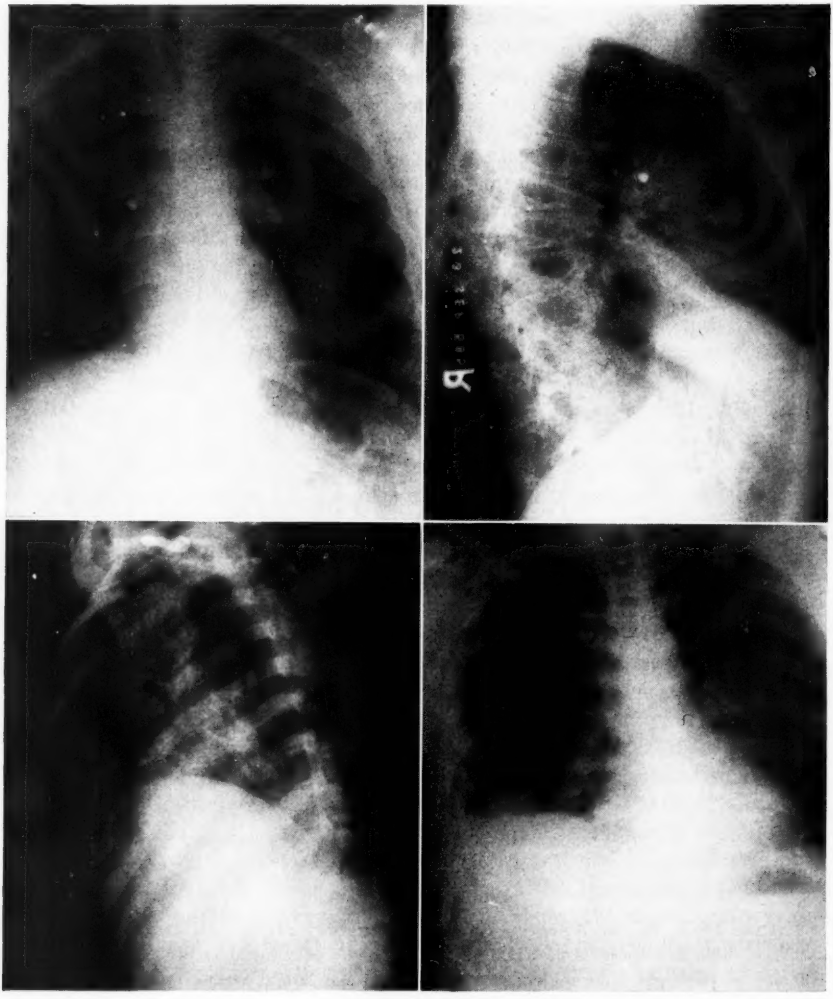


Fig. 3. Fig. 4.

Fig. 1.—A metallic foreign body is located at the level of the sixth posterior intercostal space, near the hilum, and one at the level of the fifth posterior rib at midline.

Fig. 2.—Lateral view places one metallic foreign body near the hilum and one within the anterior chest wall.

Fig. 3.—Oblique view of the chest shows multiple rib fractures and moderate subcutaneous emphysema.

Fig. 4.—Posteroanterior view shows fracture of the first to seventh ribs with the lung expanded.

costal space inclusive. Blood was aspirated from the right pleural space in five consecutive days with clearing of the previously blurred costophrenic sinus and subcutaneous emphysema to a great extent (Figs. 3 and 4).

This is a representative case of crush injury which responded well to conservative measures.

Fig. 5.

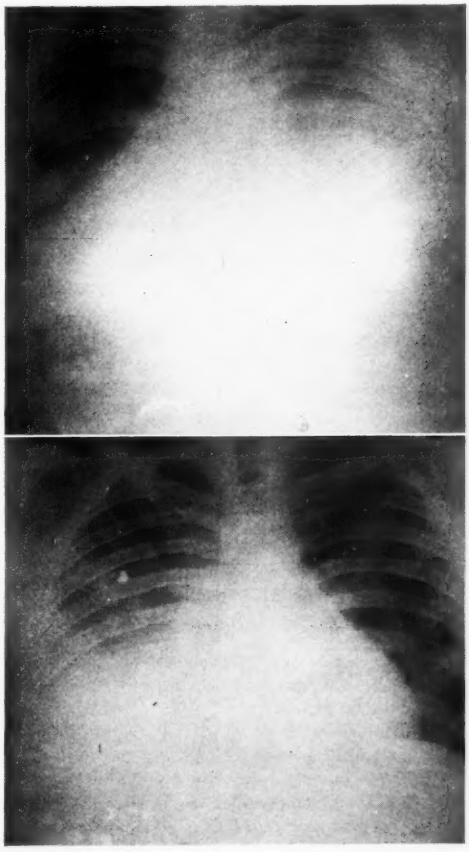


Fig. 6.

Fig. 5.—Massive hemothorax on the right.

Fig. 6.—Considerable clearing of the right lung field with a metallic foreign body present within the lung parenchyma.

CASE 3.—C. L. S., a 23-year-old American corporal, was admitted thirteen hours after he sustained shell fragment wounds of the back and legs. At the time of admission he complained of pain in the right chest and expectorated a moderate amount of blood. A 1 by 1 cm. in diameter bleeding wound was present over the right lower chest wall near the paraspinal line. Physical examination revealed depressed breath sounds on the right side of the chest. Roentgenogram of the chest (Fig. 5) showed massive clouding on the right with a metallic foreign body retained within the lung. Débridement of the wounds was done.

Three aspirations of blood from the right pleural space led to considerable clearing of the right lung field (Fig. 6). Nine days following admission, this patient was evacuated in asymptomatic condition.

This is a representative case of hemothorax which responded well to repeated aspirations.

CASE 4.—K. Y. S., a 17-year-old South Korean soldier, sustained a penetrating shell fragment wound of the left chest with the entrance wound at about the seventh intercostal space at the midaxillary line resulting in left hemothorax (Fig. 7). Two successive aspirations of blood from the left pleural space led to some clearing of the lung field. The patient expectorated a considerable amount of blood, and showed evidence of atelectasis of the right lower lobe two days following admission. Bronchoscopic suction, encouraged coughing regime, and repeated pleural aspirations on the left side led to good clearing of both lung fields (Fig. 8). He was asymptomatic at the time of his evacuation, four days following admission.

This is a representative case of hemothorax and atelectasis which responded well to repeated aspirations, bronchoscopic suction, and encouraged coughing regime.

CASE 5.—V. F. K., an American private first class, sustained perforating bullet wounds of the left chest causing hemothorax and intrapulmonary hemorrhage within the left upper lobe region. The missile entered at the fourth intercostal space and parascapular line and left the chest at about the anterior end of the first rib. Aspiration revealed 1,200 c.c. of bright red blood, followed by 200 c.c. at the time of second aspiration on the same day. Under general endotracheal anesthesia, the wounds were débrided and the pleural space was aspirated by a thoracotomy tube through the débrided wounds which were sucking at this stage of the operation. As the tube was removed, the wounds were closed with 0 chromic catgut interrupted sutures up to skin level. Three days later aspiration revealed 400 c.c. of dark blood. The next day aspiration failed to reveal blood, and the patient was evacuated in an asymptomatic condition with the lung fully re-expanded.

This is a representative case of sucking perforating wounds of the chest with hemothorax and pulmonary hematoma.

CASE 6.—J. R. H., a 20-year-old American private, sustained perforating gunshot wounds of the right chest. He was admitted twelve hours after the injury, complaining of pain and dyspnea. He had marked subcutaneous emphysema of the chest wall. The entrance wound was located at about the level of the fourth rib in the interscapular space, and the exit wound at the right supraclavicular region and midclavicular line. The latter was sucking while handled. X-ray findings (Fig. 9) showed hemopneumothorax, comminuted fracture of the outer half of the right clavicle, and depressed fracture of the second, third, and fourth ribs. Prior to surgical intervention 400 c.c. of blood and a large amount of air were aspirated. Under endotracheal anesthesia the wounds were débrided, loose clavicle and rib particles were removed, the irregular clavicle and rib ends were resected, the pleural space was aspirated, and a thoracotomy tube was inserted into the pleural space in a dependent position. The wound was closed in layers. Six days following admission, he was evacuated in asymptomatic condition. X-ray pictures showed complete lung re-expansion with only parenchymal clouding present (Fig. 10).

This patient exemplifies sucking chest wounds with depressed fracture of ribs and hemopneumothorax.

CASE 7.—E. J. G., a young American soldier, was admitted five and one-half hours after he sustained a penetrating bullet wound of the right chest. At the time of admission he complained of hemoptysis and dyspnea, and had marked subcutaneous emphysema which

Fig. 7.

Fig. 8.

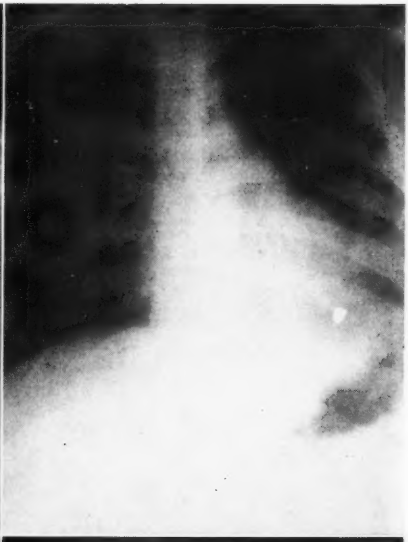


Fig. 9.

Fig. 10.

Fig. 7.—Hemothorax on the left, atelectasis of the right lower lobe.

Fig. 8.—Both lung fields appear to be normal.

Fig. 9.—Depressed fracture of the right clavicle, second, third, and fourth ribs with hemopneumothorax. The apex of the lung is at the level of the sixth posterior rib.

Fig. 10.—The lung is re-expanded. There is only evidence of parenchymal clouding present.

progressed while under observation. X-ray examination showed hemopneumothorax on the right, fracture of the sixth posterior rib, and a freely movable bullet within the pleural space (Figs. 11, 12, and 13). Under general endotracheal anesthesia the entrance wound was débrided and enlarged, and the fractured rib ends were resected to sufficient length to allow the entrance of the examining hand into the pleural space. A 31 caliber Russian carbine bullet and a large amount of clotted blood were evacuated from the pleural space. This

Fig. 11. Fig. 12.

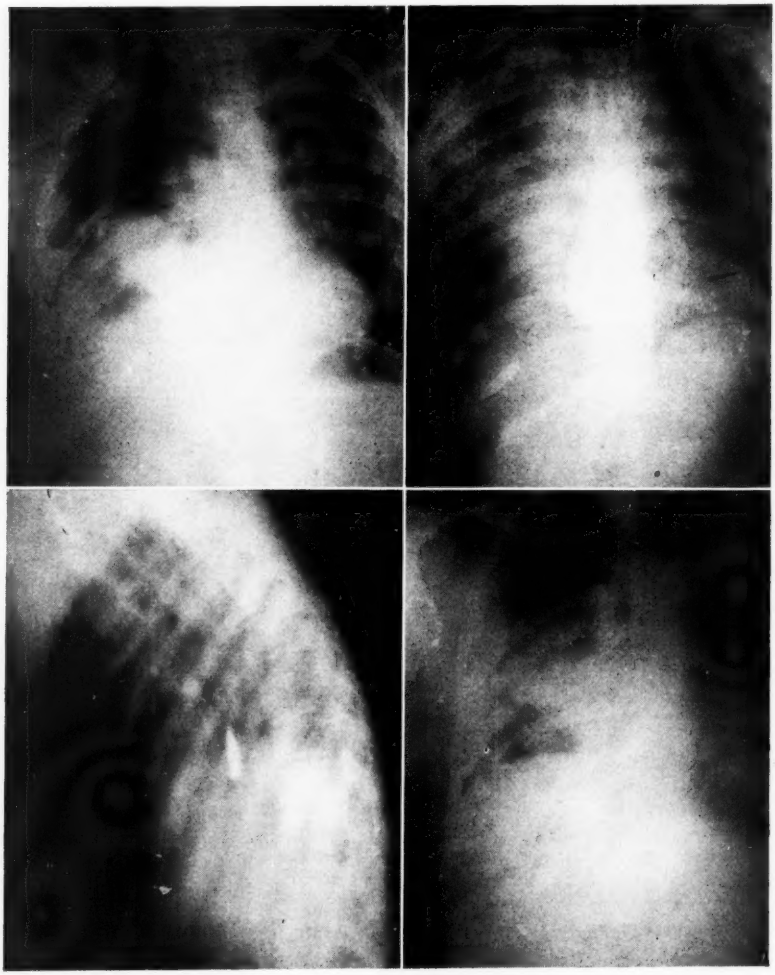


Fig. 13. Fig. 14.

Fig. 11.—Right hemopneumothorax and depressed fracture of the sixth rib.
Fig. 12.—The bullet is at the level of the eleventh rib, its point is downward.
Fig. 13.—Lateral view shows the bullet pointing upward.
Fig. 14.—The right lung is fully expanded. There is evidence of some localized pleural thickening and also of some parenchymal clouding.

was irrigated with saline solution, a thoracotomy tube was inserted in a dependent position, and the chest wall wound was closed in layers. Six days following admission, at the time of his evacuation, the patient was asymptomatic and the lung was fully re-expanded (Fig. 14).

Fig. 15. Fig. 16.

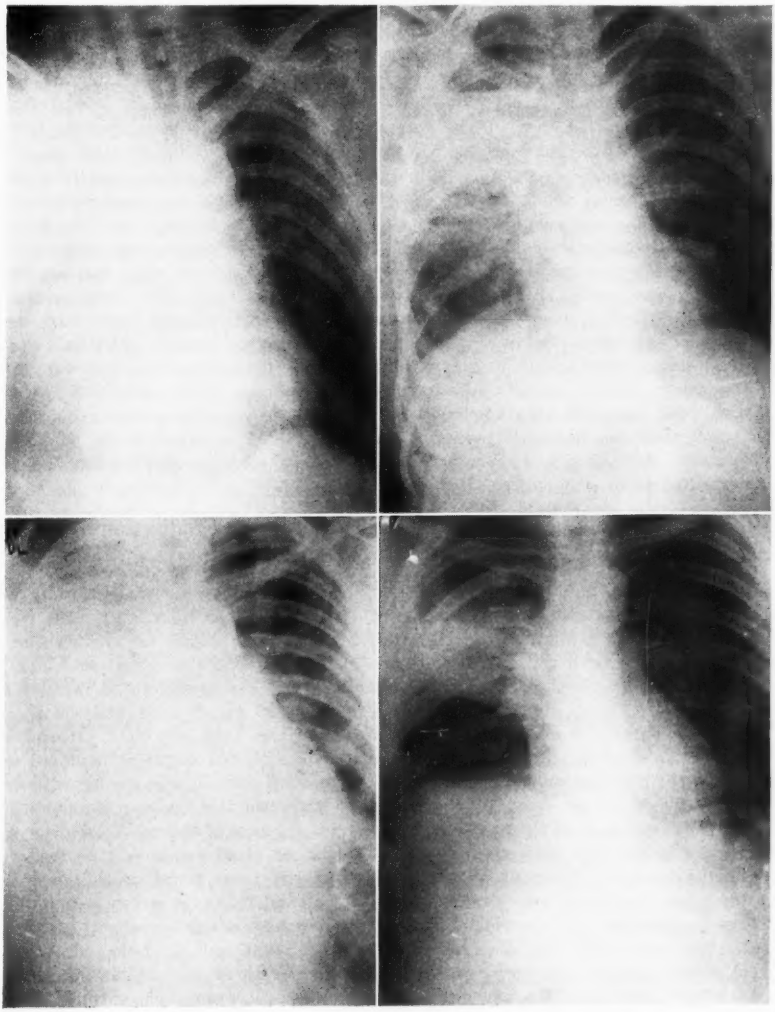


Fig. 17. Fig. 18.

Fig. 15.—Massive hemothorax on the right. Fracture of the third anterior rib.

Fig. 16.—The right lung is expanded. There is evidence of clouding at the site of the repaired lung injury. There is also evidence of fluid level at the height of the fourth posterior intercostal space.

Fig. 17.—Massive hemothorax on the right.

Fig. 18.—The right lung is fully re-expanded and shows evidence of parenchymal clouding at the site of the repaired lung wound.

This is a case with intrapleural metallic foreign body. The patient was submitted to a modified thoracotomy.

CASE 8.—H. L. S., a 21-year-old American sergeant, was wounded by a hand grenade which exploded in his right hand. He was admitted 6 and one-half hours following the injury in shock, acute respiratory distress, a bleeding and sucking wound of the right anterior chest, avulsion of the right hand, and shell fragment wound of the jaw. The sucking, bleeding wound measured about 2½ by 1½ inches and was located at the anterior end of the first rib. X-ray view (Fig. 15) showed massive hemothorax on the right, and fracture of the third anterior rib at the midaxillary line. The patient received 1,500 c.c. of blood before he was taken to the operating room. Under general endotracheal anesthesia an open thoracotomy was performed with anterior approach. A "Y"-shaped fracture of the liverlike upper lobe was found almost completely dividing the lower half of the anterior and posterior segments of the upper lobe in an anteroposterior and lateral direction. The torn lung surfaces were bleeding profusely. One metallic foreign body was removed from the lung. The bleeding points were controlled with 000 silk ligatures. The débrided lung surfaces were approximated with 00 chromic catgut mattress sutures with the incorporation of eight Gelfoam strips. The visceral pleura in the area of the tear was also approximated. The pleural space was evacuated and irrigated, two thoracotomy tubes were inserted into the right chest cavity, and the wound was closed in layers. The sucking wound of the anterior chest wall was débrided and closed, assuring full lung re-expansion at the conclusion of the procedure. Also a circular amputation of the right midforearm was performed. At the time of the patient's evacuation eight days following admission, the lung was re-expanded with the exception of a small anterior upper lung field pocket of fluid (Fig. 16) from which 40 c.c. serous fluid was aspirated. According to a follow-up report, two months later, both lung fields appeared to be normal on x-ray examination.

In this case, active intrapleural bleeding was the indication for formal thoracotomy.

CASE 9.—W. R., a 23-year-old American private, wounded himself accidentally while cleaning his rifle. He sustained perforating bullet wounds of the right chest. The patient was admitted in shock two hours after the injury. The entrance wound was at the costochondral junction of the third and fourth anterior ribs, and the exit wound just outside of the scapula, at about the level of the fourth posterior rib. Roentgenogram showed massive hemothorax on the right (Fig. 17). Aspiration revealed 820 c.c. of blood, and 800 c.c. next day, with no appreciable change in the appearance of the right lung field. He received 2,500 c.c. of blood during the period of observation. His general condition improved somewhat though the blood pressure remained 90/70. It was felt that we were dealing with active intrapleural bleeding. An open thoracotomy was performed through a posterolateral approach. The lower part of the anterior and posterior segment of the upper lobe was traversed by the bullet tract from which oozing of bright red blood was noted. In the middle of the bullet tract a cartilage about 1 by 1 cm. in diameter was found in addition to dirt. Near the lower margin of the entrance wound the internal mammary artery was torn, and found to be spurting into the pleural space. The bleeding internal mammary artery was ligated. The lung wound was débrided, irrigated with normal saline solution, and repaired with 00 chromic catgut interrupted mattress sutures. Two throacotomy tubes were inserted into the pleural space, and the operative wound was closed in layers. The entrance and exit wounds were débrided and closed up to skin level. The patient made an uneventful recovery, and ten days following surgery, he was evacuated in an asymptomatic condition. The wound was healed and the lung was fully re-extended, showing only parenchymal clouding at the site of the débrided and sutured lung wound (Fig. 18).

Intrapleural active bleeding was the indication for open thoracotomy in this case.

CASE 10.—A. D., a 20-year-old American sergeant, had sustained perforating missile wounds twelve hours before admittance. The bullet entered at the left side of the neck and traversed the mediastinum, right chest, and right upper arm. He was in marked respiratory distress, and had extensive subcutaneous emphysema of the neck above the sternum and right side of the chest wall. He appeared to be moribund. The entrance wound (½ cm. in diameter) was located at about the mid-part and just posterior to the sternocleidomastoideus muscle on the left side; the exit wound, about 2 by 1 inches in diameter, was at the posterior surface of the right upper arm. An x-ray view showed hemopneumothorax and fracture of the third anterior rib on the right (Fig. 19). Open thoracotomy was performed with anterior approach through the third intercostal space, followed by exploration of the left side of the neck, and tracheotomy. The bullet entered the left side of the neck, perforated the left lobe of the thyroid gland, tore an area nearly 5 mm. in diameter on the anterior wall of the cervical trachea, perforated the upper mediastinum and the upper lobe of the right lung, fractured the third anterior rib, changed its direction through the axilla, and perforated the right upper arm, leaving it, over its posterior surface. At the time the mediastinal pleura was opened a considerable amount of air was escaping from the upper mediastinum. Its structures were carefully inspected and two large Penrose drains were placed into the mediastinum, the ends of which later were brought out through the neck. The perforating wounds of the upper lobe were débrided, the 2-inch long tract was cleansed with saline solution, the entrance and exit wounds were closed with 00 chromic catgut sutures after two strips of Gelfoam were placed into the bullet tract. The irregular ends of the fractured third rib were resected. The pleural space was irrigated, two thoracotomy tubes were placed into the pleural space, and the chest wall wound was closed in layers. The left side of the neck was explored through an incision anterior to the sternocleidomastoideus muscle; the ends of the Penrose drains placed into the upper mediastinum through the chest were brought out through the neck wound. The tear of the anterior wall of the cervical trachea was débrided, and through a stab wound of the anterior surface of the neck, it was used for tracheotomy. The neck wound was loosely approximated and the entrance and exit wounds of the bullet were débrided. The patient had considerable respiratory difficulty during the first two days after the operation, though the lung was fully re-expanded at this time. As soon as the air escape from the mediastinum lessened, anoxemia eased, and the color of the patient improved considerably. Six days following operation, he was discharged in excellent general condition with the lung fully re-expanded (Fig. 20), the wounds were clean and healing, and the tracheotomy functioned properly.

In this case the mediastinal perforation and emphysema represented the indication for open thoracotomy.

CASE 11.—C. A., an 18-year-old American private first class, sustained perforating bullet wounds nine hours prior to admission. The entrance wound was located at about the seventh intercostal space at the midclavicular line, the exit wound at about the twelfth rib at the parascapular line. The abdomen was tender to palpation with muscle spasm present at the right upper quadrant. Posteroanterior chest x-ray pictures showed no apparent lung pathology. Exploratory laparotomy was performed through a right paramedian incision. Massive pulpous laceration of the liver was found with destruction of the outer two-thirds of the right lobe in addition to perforation of the diaphragm and anterior chest wall. The loose liver particles were removed, the liver wound was controlled by Gelfoam and chromic No. 1 mattress sutures. The diaphragmatic tear was closed with No. 1 silk sutures, while the pleural space was evacuated and kept free of blood by a thoracotomy tube which was inserted temporarily through the diaphragmatic tear and removed while the last suture was tied. One large Penrose drain was placed above and one below the right lobe of the liver and brought out through the flank. The abdominal wound was closed in layers. The entrance and exit wounds were débrided and closed up to skin level. X-ray views of the chest the next day showed complete lung re-expansion. Subsequently the right diaphragm showed evidence of gradual rise due to liver tissue breakdown. Ten days following surgery, the

patient was evacuated for drainage of the right subdiaphragmatic space. The lung field remained clear, except for the compression caused by the elevation of the right diaphragm. Subsequently the subdiaphragmatic space was evacuated with uneventful postoperative course.

Fig. 19. Fig. 20.

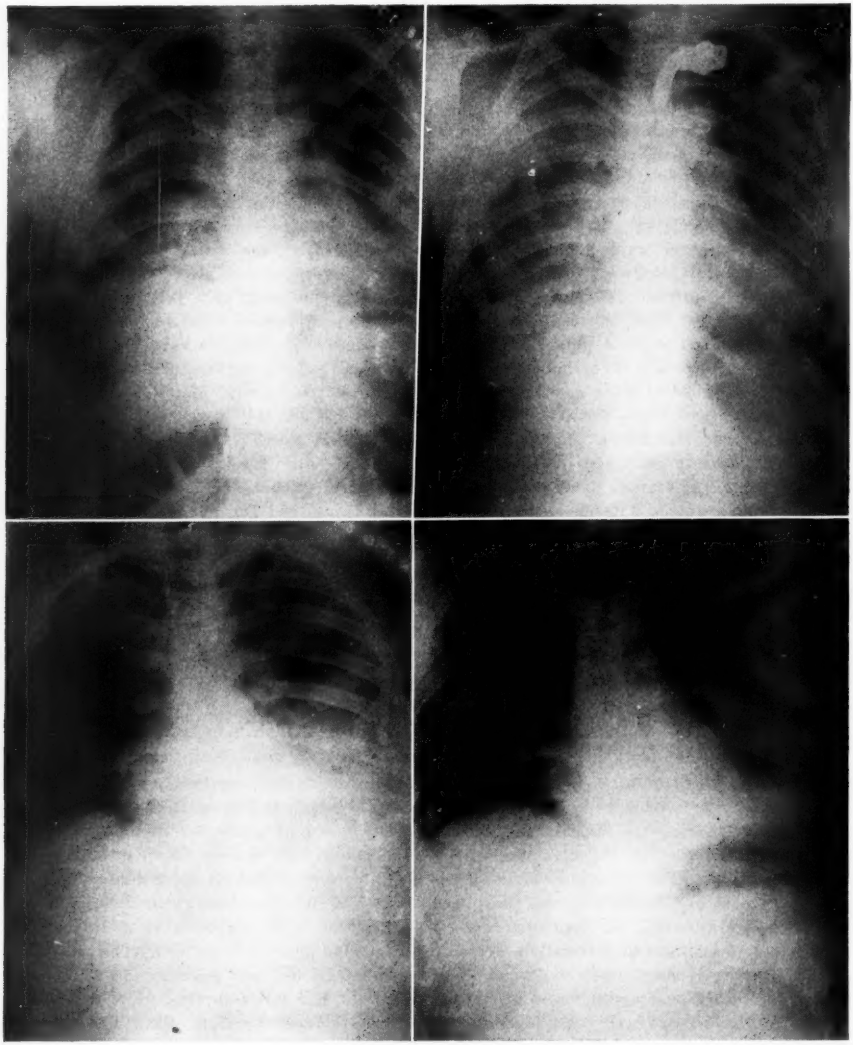


Fig. 21. Fig. 22.

Fig. 19.—Hemopneumothorax on the right and fracture of the third anterior rib.

Fig. 20.—The right lung is fully expanded.

Fig. 21.—Left hemothorax with one metallic foreign body above and two below the diaphragm.

Fig. 22.—The lung is fully expanded and shows no other abnormalities than a retained metallic foreign body.

This case is an example of the type of thoracoabdominal injuries which can be treated successfully by laparotomy and closure of the diaphragm from the abdominal side.

CASE 12.—J. M., a 22-year-old American private first class, sustained three shell fragment wounds of the left chest, each of them measuring about 2 by 2 cm. in diameter. The abdomen was tender to palpation with muscle spasm present. A posteroanterior chest x-ray picture (Fig. 21) showed evidence of hemothorax on the left side with one metallic foreign body located above and two metallic foreign bodies located below the diaphragm. Aspiration of the left pleural space revealed 100 c.c. of blood of putrid odor. Streptomycin, ½ Gm., and 400,000 units of penicillin were instilled into the pleural space aand 1 Gm. of streptomycin and one million units of penicillin were given intramuscularly. Under general endotracheal anesthesia, laparotomy was performed through a left midrectus incision. The

Fig. 23.—There is evidence of considerable distention of the gastrointestinal tract.

findings were as follows: Massive peritonitis with large amount of blood and fecal material in the peritoneal cavity; the splenic flexure of the colon showed numerous, confluent irregular openings about 8 inches long; there was an opening about 1½ inches in diameter in the left leaf of the diaphragm. The splenic flexure of the colon measuring about 10 inches was resected; the clamped stumps were brought out through stab wounds of the right and left upper quadrants of the abdomen. The peritoneal cavity was evacuated and cleansed. The diaphragmatic tear was closed with No. 1 silk mattress sutures while the pleural space was aspirated with the help of a tube inserted through a perforation of the diaphragm. The patient's condition was poor, therefore irrigation of the pleural space and débridement of the chest wall were delayed. The laparotomy wound was closed with through-and-through wire sutures. Next day the patient's general condition was improved; the blood pressure was 100/60. Under 1 per cent procaine infiltration anesthesia the three chest wall wounds were débrided and two thoracotomy tubes were inserted into the pleural space through which foul-smelling, bloody material was aspirated. This was followed by extensive irrigation of the pleural space with hydrogen peroxide solution. The irrigation was repeated every three hours until the returning fluid had no smell any longer (within forty-eight hours), when the

lung was allowed to re-expand fully. On the third postoperative day the thoracotomy tubes were removed. X-ray examination (Fig. 22) on the fifth postoperative day showed fully expanded well-aerated lung fields on both sides though the general condition was poor. The abdomen was distended, bowel sounds could not be heard, and the urinary output was inadequate. The clinical picture was of adynamic ileus and uremia of which the patient died on the sixth postoperative day.

This case represents a thoracoabdominal injury with diaphragmatic tear, handled by laparotomy and closure of the diaphragm from the abdominal side.

CASE 13.—C. L. H., a 19-year-old American private first class, was admitted twenty-eight and one-half hours after he was wounded. He sustained perforating thoracoabdominal wounds. At the time of admission he had marked dyspnea, hemoptysis, left chest pain, and marked distention of the abdomen (Fig. 23). The bowel sounds could not be heard. The entrance wound was located at the level of the fourth rib at the anterior axillary line on the left side and measured about ½ cm. in diameter; the exit wound was located at the right flank and measured 4½ by 2 cm. in diameter. X-ray pictures of the chest showed no evidence of gross injury of the lung. A laparotomy was performed through a left midrectus incision. In order to expose the cardiac end of the stomach and retrocardiac space the incision was extended upward and the seventh, sixth, fifth, and fourth cartilages were divided making the procedure an abdominothoracic one. The findings were as follows: perforating wounds of the left lower lobe with an egg-sized hematoma of the anteromesial basal segment of the left lobe; a perforation about ¾ cm. in diameter of the left leaf of the diaphragm, near to the cardiac end of the stomach; an egg-sized hematoma at about, and posterior to, the cardiac end of the stomach and lower end of the esophagus; a retroperitoneal hematoma extending from the level of the cardia to the bifurcation of the abdominal aorta, behind the left colon and duodenum; extensive laceration of the lower half of the right kidney; considerable distention of the entire intestinal tract, left hemothorax, and large hemoperitoneum. The left pleural space was evacuated; the lung wounds were cleansed with saline solution. The lower retroesophageal and retrocardiac space was explored; the hematoma was evacuated. The retroesophageal space extending to the common iliac artery, and behind the right colon and duodenum, was inspected. A right nephrectomy was performed and the entire intestinal tract surveyed. The chest wound was closed in layers. A thoracotomy tube was placed into the left pleural space in a dependent position. A Penrose drain was placed into the right renal bed and brought out through a stab wound at the right flank. The abdominal wound was closed with through-and-through wire sutures. The entrance and exit wounds were débrided. The patient made an uneventful recovery. X-ray pictures taken two days before evacuation on the sixth postoperative day showed the lung well expanded with no gross abnormalities visible. Follow-up report in one month revealed a continued uneventful course. The wound healed well, the costal arch was firm, and the patient was reported to be asymptomatic.

This case represents one of the indications for abdominothoracic exploration.

CASE 14.—F. H., a 27-year-old American sergeant, was wounded eleven hours prior to admission. He sustained a shrapnel wound of the right flank. His general condition was fairly good. There was a wound 4 by 4 inches in diameter, at the right flank. The abdomen was tender all over with rigidity present. The urine was red. X-ray view of the chest showed some clouding of the periphery of the right lung field with a large metallic foreign body retained within the upper part of the chest (Fig. 24). A laparotomy was performed through a right rectus incision. A one-inch laceration of the undersurface of the right lobe of the liver and contusion of the right kidney were found in addition to moderate amount of blood in the peritoneal cavity. The right kidney and ureter were explored and the intestinal tract was surveyed. One Penrose drain was placed to the liver laceration and one to the kidney capsule; both were brought out at the right flank. The operative wound was closed with through-and-through wire sutures. The entrance wound was débrided. An incision was

made, extending about 6 inches upward, exposing the tract of the shell fragment, and the comminuted, fractured twelfth, eleventh, and tenth ribs with a tear of the parietal pleura at about the costophrenic sinus. By the time this wound was cleansed, and loose bony particles

Fig. 24.

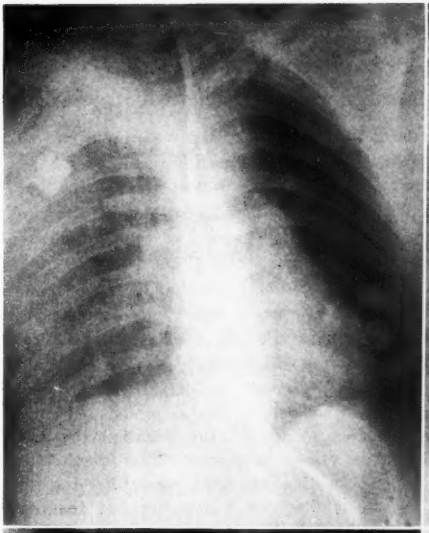
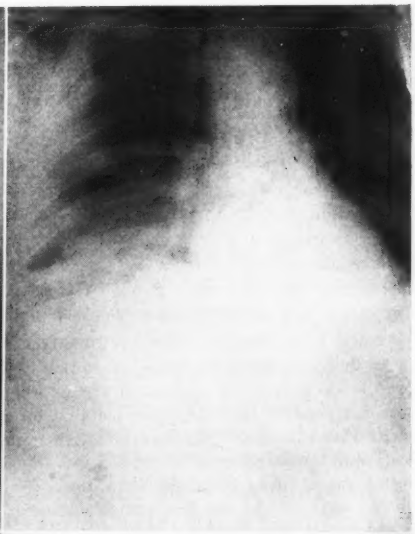


Fig. 25.



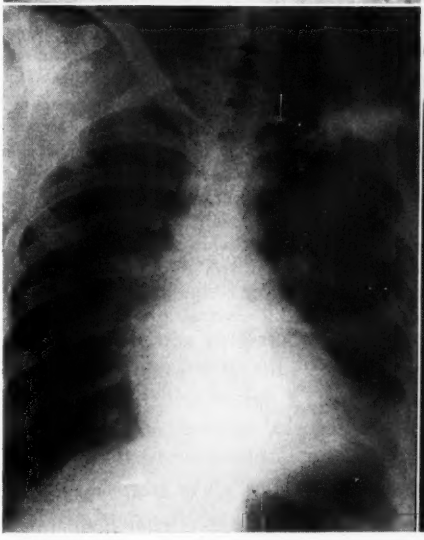


Fig. 26.

Fig. 27.

Fig. 24.—Hemothorax on the right with large metallic foreign body retained within the upper lung field.

Fig. 25.—The right lung is re-expanded. There is only evidence of localized pleural thickening.

Fig. 26.—A metallic foreign body is present within the heart shadow.

Fig. 27.—The metallic foreign body is located anteriorly.

and torn soft tissues were excised, the torn kidney capsule was in view and the chest wall opening was large enough to insert the surgeon's hand and a metallic foreign body about 2 by ¾ by ¾ inches was removed from the right pleural space. The metallic foreign body was stuck on the outer surface of the right upper lobe. The pleural space was irrigated, two thoracotomy tubes were inserted in dependent positions, and the chest wall defect was closed by approximating the overlying soft tissues in layers. The patient made an uneventful recovery. Seven days later x-ray pictures (Fig. 25) showed complete lung re-expansion with only localized pleural thickening present.

This case falls into the group of modified thoracoabdominal explorations.

CASE 15.—B. L. S., a 22-year-old American corporal, was admitted twelve and one-half hours after he was wounded. He sustained penetrating shell fragment wounds of the left forehead, left elbow, and upper abdomen. There was an entrance wound about 3 by 1 cm. in diameter at about the seventh rib and midaxillary line on the left side. The abdomen was tender to palpation and rigid. Posteroanterior and lateral x-ray pictures of the chest showed an irregular metallic foreign body near or at about the heart shadow (Figs. 26 and 27). A laparotomy was performed through left paramedian incision. A tangential laceration about 1½ inches long of the dome of the left diaphragm and a bleeding laceration about 2 inches long and 1 inch deep of the upper surface of the left lobe of the liver were found. The liver laceration was controlled by No. 1 chromic catgut mattress sutures, the hemoperitoneum was evacuated, and all the abdominal organs were inspected. Through the diaphragmatic tear it was not possible to palpate the metallic foreign body and since it was suspected to be near or at about the heart, the laparotomy incision was extended upward, the seventh, sixth, fifth, and fourth cartilages were divided, and the operative wound continued in the fourth intercostal space up to the midaxillary line. With the help of a self-retaining retractor an excellent exposure of the heart was obtained. At about the apex a hematoma of the pericardium was found. The pericardium was opened and clotted blood was evacuated from the pericardial cavity. A perforation of the right ventricle about 2 cm. long and ½ cm. wide was found. This wound was located near the septum in the neighborhood of the apex. While the patient received intravenous procaine and procaine was applied topically, through-and-through doubled 00000 braided silk sutures were placed into the heart muscle, traversing the laceration. The operator's left index finger was inserted into the right ventricle through the laceration, and the metallic foreign body was palpated and brought down to the area of the laceration. It could be removed only with an extension of the laceration about ½ cm. After the metallic foreign body was extracted, the previously placed silk sutures were tied. During this procedure very little blood was lost. In about two or three minutes after the procedure was completed, the heart contractions slowed down and the ventricular contractions became weak and irregular. Cardiac massage was started immediately with resulting good heart action lasting only for about four to five contractions followed by a repetition of weakening of the ventricular contractions until almost ventricular standstill occurred. At this stage the cardiac massage was resumed with the same result. This vicious circle existed for two hours and forty-five minutes, when cardiac massage resulted only in incoordinated muscle fiber contractions followed by complete cessation of the heart action.

This case represents one of the indications for abdominothoracic exploration.

DISCUSSION

In the management of these patients well-tested conservative principles were applied. The value of repeated needle aspiration of hemothorax and hemopeneumothorax is well established.[5-9] In addition, some changes in the indications for surgical interventions and some modifications of the methods of treatment of similar wounds during World War II were made.

The débridement and closure of sucking wounds of the chest and aspiration of the pleural space through the débrided wounds under general endotracheal anesthesia were found to be very effective. Only a few of the patients treated by this method needed subsequent needle aspirations. The value of this procedure was emphasized by Snyder[5] in 1945. The assurance of complete evacuation of the pleural space and full lung re-expansion at the time of the wound closure explains the good results.

The indications for open thoracotomy were few, seventeen in number, representing 12.9 per cent of all the chest injuries. In nine of them the chest was entered through an elective anterior incision (Diagram 1, *A*, *B*, *C*, and *D*). The idea of this technique was developed from an approach frequently used for elective lung resection.* The magnitude of the thoracotomy was considerably lessened when the anterior approach was used. This proved to be the quickest method of entering the chest. The exposure was adequate and the wounds healed well. This was substantiated by follow-up reports.

Perforation of the diaphragm or the anatomic likelihood of such was not found to be an indication for formal thoracotomy. These patients were submitted to laparotomy and the diaphragmatic tear was closed from below as described previously. The likelihood of missing intra-abdominal injuries, if the exploration is done through the chest, is great. A thorough inspection of the intra-abdominal structures in such cases must be carried out. This cannot be accomplished as well through a thoracotomy wound as through a laparotomy incision, even if the thoracotomy incision is placed low and the diaphragm is divided.

The indications for exploring the chest as well as the abdomen in thoracoabdominal injuries are limited. Among the thirty-six thoracoabdominal injuries reported here, this was accomplished in thirteen, or 36 per cent, of the cases. In eight of these patients the anterior abdominothoracic approach, previously described, was used (Diagram 2, *A*, *B*, *C*, and *D*). This was a combination of a laparotomy with only the vertical part or the entire anterior thoracotomy incision, which converted the thoracic and abdominal cavity into a single operative field and gave an excellent exposure. It provided easy access to parts of the abdominal cavity which could not be gained by separate approaches to the chest and abdomen. It proved to be the quickest way to expose the abdomen and the chest. The patient remained on his back throughout the procedure, which is the least disturbing position from the physiologic point of view. The wounds healed well and the costal arch became firm and stable. This was substantiated by follow-up reports.

In cases of acute emergencies such as war injuries the proposed anterior thoracoabdominal incisions were found to be most satisfactory, in contrast to the excellent thoracoabdominal approaches of Harper,[11] Garlock,[12] Carter,[13] Humphreys,[14] and others which were proposed primarily for elective conditions.

*By Dr. Samuel Alcott Thompson of New York, N. Y.

SUMMARY

An analysis of 163 thoracic and thoracoabdominal injuries handled at a Mobile Army Surgical Hospital in Korea was presented. Twelve of these patients died, representing a mortality of 7.3 per cent.

Indications for surgical intervention were enumerated and the methods of treatment described.

A conservative attitude in the treatment of most of the chest injuries was emphasized.

The advantages of laparotomy in contrast to thoracotomy in the management of some of the thoracoabdominal injuries were stressed.

An anterior approach for thoracotomy and an approach for anterior abdominothoracic exploration were presented.

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MANAGEMENT OF WAR WOUNDS OF THE CHEST*

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ALTHOUGH the initial mortality of thoracic wounds sustained in combat is relatively high, the estimated delayed mortality experienced in the Korean conflict has been lower than that reported during the last two wars in which the United States has been involved. We have profited from the experiences of the physicians who served in the last war, and thus have a more complete understanding of chest physiology as related to derangements resulting from war wounds and greater knowledge of treatment of primary and secondary shock.[1, 2, 6, 8, 9, 10, 19] We have new and more effective antibiotics, the Mobile Army Surgical Hospitals which give emergency treatment within a few miles of the front lines, and a more rapid system of medical evacuation, all which have done much toward decreasing the delayed deaths from chest wounds. Consequently, there has been greater opportunity for more definitive treatment of these patients with better final results.[20]

In this paper we make no attempt to give any over-all statistics concerning war wounds of the chest during this conflict, but only to analyze our experiences with the 1,535 chest casualties which were channeled through Tokyo Army Hospital between the beginning of the conflict and January, 1952. It is our understanding, however, that the majority of the chest casualties were sent to Tokyo Army Hospital.

The average chest casualty is seen first by the company aid man who applies an emergency dressing and is then evacuated by litter bearers, jeep ambulance, or helicopter to a battalion aid station where he may be given plasma or whole blood for replacement or to combat shock. Sedation is administered judiciously. The next step is movement to either a Mobile Army Surgical Hospital or an evacuation hospital by jeep, ambulance, or helicopter. Here emergency surgery, such as débridement and closure of the wound, is performed by surgical teams. Depending upon the patient's condition, he is moved on within forty-eight hours by ambulance, or by air to a field hospital or to a station hospital where he may remain for two to eight days. Following this he is transferred to a hospital ship or, more frequently, is flown to a general hospital in Japan. It should be noted that the system of evacuation is flexible enough to permit evacuation from the Mobile Army Surgical Hospital directly to general hospitals, so that many patients arrive in Japan 36 hours after being wounded, a tribute to the system of air evacuation. However, most patients arrive at Tokyo Army Hospital within six days after being wounded. Some patients who were evacuated aboard hospital ships re-

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quired as long as thirty days en route. However, their treatment during this time paralleled treatment rendered at the general hospital. Definitive treatment is administered in the general hospital, and the patient is returned to duty or evacuated to the United States by air, depending upon his condition and the evacuation policy in force at the time. The patients from other United Nations countries are sent to their homelands.

In the early stages of the conflict, casualties could be hospitalized in Japan for only thirty days, thus making definitive treatment difficult to ascertain in many cases. However, as the bed capacity in the theater increased, the period of hospitalization was increased to 120 days, thus making definitive treatment of chest wounds practical.

It is worth mentioning that Tokyo Army Hospital is a United Nations installation staffed by United States military personnel. Patients were chiefly U. S. soldiers from all branches of service. We also cared for soldiers from all parts of the British Commonwealth, Turkey, Greece, France, Belgium, Thailand, Philippine Islands, Ethiopia, Colombia, and Puerto Rico. Most of the foregoing countries contributed nurses to the hospital staff, who also acted as interpreters. Despite their help, considerable language difficulties were encountered, thus complicating symptoms, diagnosis, and treatment.

The cases in this study do not include those consisting of superficial wounds of the chest wall, but deal primarily with wounds of the intrathoracic viscera solely, or in combination with wounds of the abdomen, nervous system, skeleton, etc.

War wounds, as a result of missiles propelled by explosives, may be classified as penetrating or perforating types. Penetrating wounds are those resulting from entrance of a missile with retention of that object as a foreign body regardless of the size of the wound of entrance. There is no wound of exit. Penetrating wounds are usually caused by mortar fire, artillery fire, hand grenades, land mines, small arms fire, in that order of frequency. Usually the more severe wounds are of this type. Perforating wounds result from the through-and-through passage of a missile with a wound of entrance and a wound of exit. Approximately 90 per cent of the perforating wounds are caused by small arms fire, and the remaining 10 per cent by mortar and artillery fire, hand grenades, and land mines. In our series of cases, 1,007, or 66 per cent, of the wounds were of the penetrating type, 485, or 32 per cent, were of the perforating type, and 42, or 2 per cent, were results of crushing injuries.

The restoration of normal respiratory and circulatory physiology is the prime factor in the management and treatment of thoracic wounds.

On admission to his hospital, each patient was screened by a medical officer, and all those requiring emergency treatment were seen immediately by the thoracic surgeon on duty who rendered the necessary treatment. Roentgenograms were taken immediately, when indicated. All patients had blood counts, urinalyses, and upright chest roentgenograms. They routinely received 300,000 units of penicillin twice daily, and, if indicated, ½ Gm. of streptomycin was administered with the same frequency. Patients were

placed in beds with the head elevated to a 45-degree angle and were encouraged to cough frequently. Sedation was kept at a minimum and, for severe pain, demerol was given in doses of 50 to 100 mg. every four hours. In cases which had painful rib fractures, intercostal nerve blocks with 2 per cent procaine hydrochloride anesthesia were done.

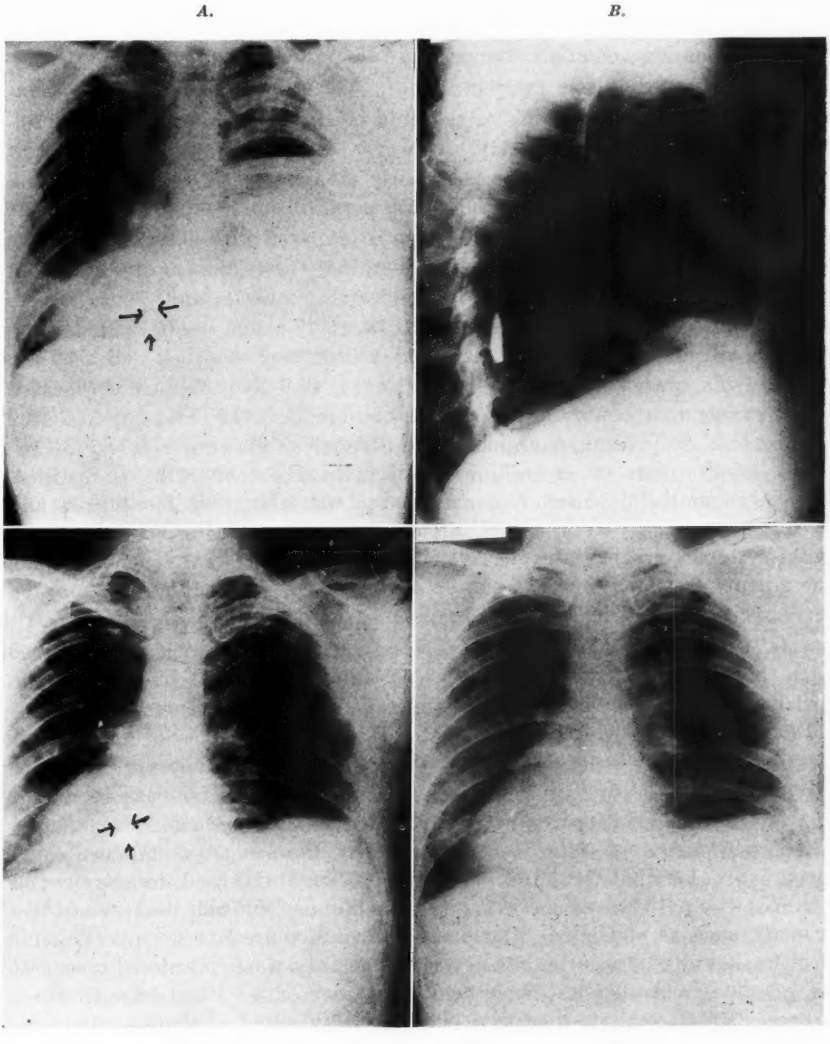


Fig. 1.—*A*, Chest film showing organized right hemothorax with retained metallic foreign body in the left lower chest. *B*, Lateral film of same patient. *C*, Roentgenogram taken after decortication of right lung. *D*, Roentgenogram taken after decortication of right lung and left thoracotomy for removal of the foreign body.

HEMOTHORAX

The most frequent complication of intrathoracic wounds is hemothorax with or without associated pneumothorax. This intrapleural blood may remain fluid or coagulate and begin to organize. It remains sterile, as a rule, but in some instances becomes infected. Of the total number of patients in our series, 952, or 62 per cent, had hemothoraces, either on admission or they developed them within the first two weeks after admission. Of this number, 704, or 74 per cent, remained sterile, and 248, or 26 per cent, became infected.

The policy here is to treat hemothorax by simple thoracentesis without air replacement. Localization of the fluid is important, since it may lie anteriorly, laterally, or posteriorly. However, it has been the experience at this hospital that it usually lies posteriorly. Aspiration is done with the patient in a sitting position, if his condition permits, under 2 per cent procaine hydrochloride local anesthesia. The skin is prepared with ether and tincture of merthiolate, and a skin wheal is raised over the most dependent portion of the fluid-filled space. The underlying muscles and pleura are infiltrated with procaine and a three-inch, 13- to 17-gauge needle with a short bevel is introduced. To this is attached a three-way stopcock and a 30 c.c. syringe. As much fluid as possible is removed, and the procedure is repeated every twenty-four hours until no fluid is obtained and the chest appears clear to physical and roentgenographic examination. Following removal of the fluid, 300,000 units of crystalline penicillin in 2 c.c. of saline is instilled. Specimens of the fluid removed are sent to the laboratory for culture and antibiotic sensitivity tests as indicated. The antibiotic of choice is administered systemically and intrapleurally, if infection is present, depending upon the manner in which the drug can be administered. Penicillin, streptomycin, terramycin, aureomycin, and Chloromycetin have been utilized.

Of the 952 patients with hemothoraces, 895, or 94 per cent, were treated with thoracenteses. The remaining 57 patients had minimal amounts of fluid which absorbed spontaneously. An average of 3.5 thoracenteses were performed on each patient, for a total of 3,082 thoracenteses. Several patients required only one aspiration, and one had twenty-five thoracenteses and ultimately required decortication.

Seven hundred fifty-five, or 79 per cent, of the patients with hemothorax completely recovered after being treated by thoracentesis and antibiotics alone. Six hundred fifty, or 68 per cent, were returned to duty. One hundred five patients were evacuated to the Zone of Interior because of other wounds, such as abdominal wounds, colostomies, central or peripheral nerve injuries, orthopedic injuries, etc., even though they were considered recovered as far as their chests were concerned. Forty-five patients had infected hemothoraces which were drained as a temporary procedure so the patients could be safely evacuated.

Many patients had clotted hemothoraces on admission to the hospital or within two days of being wounded. Apparently from a review of these

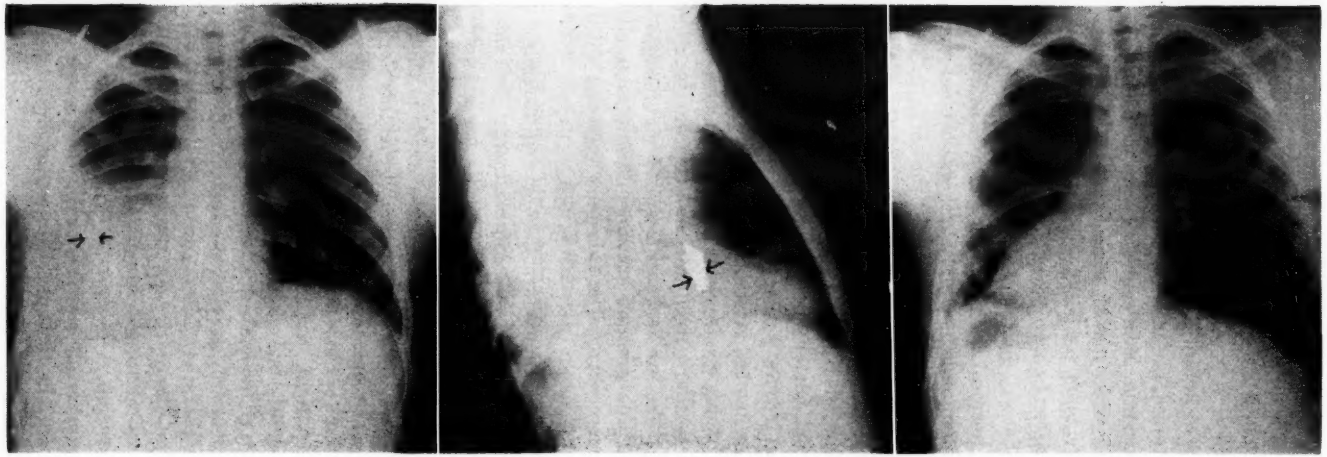
patients' records, the hemothorax clotted within a few hours after wounding, because at no time was any fluid obtained by aspiration. In other patients, the hemothorax organized gradually, taking from three to four days to two weeks.

Decortication is the established method of treatment for these patients with clotted or organized hemothoraces.[7, 11, 13, 14, 18] The first decortications were reported by Fowler in 1893[5] and Delorme in 1894.[4] The procedure was revived during World War II, with good results by Samson and Burford and others. With the advent of penicillin even better results were obtained, and consequently many patients who would have been pulmonary cripples were restored to normal life.

In short, at this hospital the operation consists of a thoracotomy through a posterolateral incision under endotracheal gas-oxygen-ether anesthesia following pentothal induction. A rib, usually the sixth or seventh, is resected, and a plane of cleavage is developed in the endothoracic fascia. As much thickened parietal pleura as possible is removed from the chest wall and diaphragm and all clot, debris, and slough are evacuated from the thoracic cavity. The thickened cortex surrounding the collapsed lung is removed. The lung is re-expanded by positive pressure, and any parenchymal tears are repaired. Foreign bodies, if present, may be removed during the operation. Two intercostal tubes are introduced, one at the level of the fourth interspace in the anterior axillary line, and the other in the eighth interspace in the midaxillary line. We use large stiff-walled right angle tubes which are attached to continuous low-pressure suction. Roentgenograms are taken daily for the next four to five days. The tubes are removed within forty-eight to seventy-two hours.

Postoperatively, the patients are encouraged to cough frequently, and are given deep breathing exercises. Approximately five days after surgery, the patients begin using a "blow bottle." We use the regulation waterseal drainage bottle filled three-fourths full with water. The patients inspire deeply, and blow the expired air through the water in the bottle. About ten days postoperatively, the patients are gathered together for ten minutes every hour and are given deep breathing exercises. They are instructed how to breathe more deeply with the affected lung than with the unaffected one. To achieve this, the patients are shown how to place their hands over the anterior lower chest and breathe against their hands. In this way, they themselves can feel that the normal side expands more than the injured one. Furthermore, they are given an exercise which causes one side of the chest to expand more than the other. The arm of the affected side is raised above the head, and the whole body is bent toward the unaffected side during inspiration. During expiration, the arm is lowered and the body is returned to normal standing position.

We feel that the importance of these exercises cannot be overemphasized. They are important aids in the rehabilitation of decortication patients and,



A. *B.* *C.*

Fig. 2.—*A*, Chest film showing organized left hemothorax with retained foreign body. *B*, Lateral film of same patient. *C*, Roentgenogram taken after decortication and removal of foreign body.

A. *B.* *C.*

Fig. 3.—*A*, Chest film showing a large left diaphragmatic hernia accompanying perforating wound of the chest. *B*, Lateral film of same patient. *C*, Roentgenogram taken after repair of hernia.

for that matter, any patient who has had a thoracotomy. They help return the diaphragm and intercostal muscles to normal function and minimize the formation of adhesions in the costophrenic angle.

One hundred fifty-two decortications were performed, without a death, on patients with both infected and noninfected organized hemothoraces. Of these, 116, or 76 per cent, were infected and 36, or 24 per cent, were noninfected. Twenty patients in this group had thoracotomies of one kind or another performed in Korea and eight had decortications, which had been done prior to admission to our hospital. Of these, 134, or 88 per cent, were considered as having good results, and were returned to duty. Of the remaining 18 patients, 10, or 6.5 per cent, were considered to have fair results, and were returned to limited duty, and 8, or 5.5 per cent, were considered as having poor results.

After performing this operation at intervals of one week to eight weeks following injury, it was decided that the optimum time for decortication is within three to five weeks of injury. In those operations performed early, the bleeding was much more severe, there was more edema, and foreign bodies, if present, were more difficult to locate.

It is worth mentioning that 92 per cent of the patients who needed decortication had closed intercostal drainage tubes inserted in Korea. Their tubes had been kept in place for from two to eight days before the patient's admission to this hospital. Not infrequently the patients arrived at this hospital with the drainage bottles placed between their legs, or resting on their chests. Not always were they properly clamped off. Due to the negative pressure inside the chest, the fluid from the bottles was often sucked back into the chest and was another source of contamination.

It is our feeling that the best early treatment for hemothorax is thoracentesis. As has been stated, those patients who had intercostal tubes inserted in Korea made up 92 per cent of those who required decortication. In such cases, subsequent aspiration was more difficult and the incidence of infection was much greater.

We used streptokinase and streptodornase, as described by Tillet and Sherry,[12, 15, 16] in 18 patients with hemothorax. One-half of these had infected hemothoraces, and the other half noninfected hemothoraces. The interval between the time of injury and the time the drugs were administered varied from four days to two weeks. Approximately 200,000 units of SK and 60,000 units of SD in 10 c.c. of distilled water were injected into the hemothorax. Eight to ten hours later the liquid portion of the hemothorax was aspirated and more streptokinase and streptodornase injected. This procedure was carried out for from four to ten days, depending upon the individual case. The drugs were injected at varied sites posteriorly, laterally, and anteriorly, and at different intercostal levels. All of our patients experienced toxic symptoms, such as high temperature, up to 105° F., general aches and pains, and occasional vomiting. Daily chest roentgenograms generally failed to show any marked change except in one case. In this patient,

A. *B.* *C.*

Fig. 4.—*A*, Chest film showing left organized hemothorax with retained large metallic foreign body. *B*, Lateral film of same patient. *C*, Chest film taken following decortication and removal of foreign body.

while the drugs dissolved some of the adhesions and the lung partially collapsed, they failed to dissolve the thickened pleura. In view of the results obtained, the use of these drugs was discontinued.

One death occurred in this group of patients with hemothorax. A patient with an empyema died of pulmonary embolism.

FOREIGN BODIES

As is well known, during war chest surgery, numerous foreign bodies are encountered in the chest wall, the pleural space, in the lung parenchyma, or mediastinum. Most of these are a result of penetrating wounds. In this hospital only those foreign bodies which exceeded 1.5 centimeters are removed, unless, of course, they are in such a location as to be regarded as dangerous to the patient or give rise to some pathologic change within the chest. Smaller foreign bodies in the region of the heart and great vessels and in the pulmonary parenchyma are observed carefully by repeated roentgenographic and electrocardiographic examinations for at least one month. If there is no evidence of reaction about the object, and the patient's condition is satisfactory, these foreign bodies are not disturbed. Persistence or development of reaction about the missile indicates the need for exploration and removal.

Of our patients, 104 had retained foreign bodies. Thirty-eight were in the chest wall accompanied by intrathoracic damage and rib fractures. Thirty-five were in the lung parenchyma, and thirty-one were in the pleural space and were removed at decortication. Eighty-five per cent of the metallic foreign bodies were shell fragments which varied in size from 1 cm. to 8 cm. in diameter. Most of these were irregular in shape with ragged edges. The remaining 15 per cent were bullets of different caliber. The incidence of infection when the foreign body was a shell fragment was quite high, being from 60 to 70 per cent. When the foreign body was a bullet, the incidence of infection was about 10 per cent.

The thirty-eight foreign bodies located in the chest wall, which are mentioned here, were those cases in which the foreign body was so located as to require thoracotomy for removal. We removed numerous metallic foreign bodies more superficially situated in the chest wall by simple procedures, and do not have figures concerning these. All of the patients in this group returned to duty.

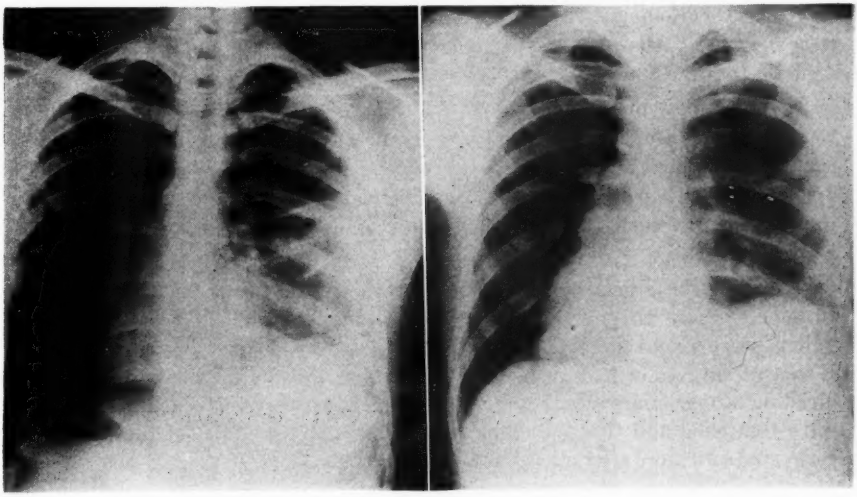
The removal of intrathoracic foreign bodies is accomplished by open thoracotomy through a posterolateral incision with resection of a rib. An incision is made in the lung surface nearest to the object and the missile is removed. Infected lung tissue is removed by wedge or segmental resection. Twenty of these patients had partial lobectomies. All 35 of them returned to duty.

Thirty-one foreign bodies were removed at the time of decortication. Twelve of these also suffered some damage to the lung parenchyma and needed

partial resections at the same time. All of these patients returned to full duty. The foreign bodies removed from the pleural cavity consisted not only of shell fragments and bullets, but pieces of clothing, fountain pens, and in one case an olive.

Of the 37 patients admitted to this hospital who had thoracotomies performed in forward areas, 23 were thoracotomized apparently solely for the removal of a foreign body. Although the patients ultimately recovered, we considered 35 per cent of them to have a poor result because recovery was slower and the amount of fibrosis present was greater, thus diminishing pulmonary function. Eight of these patients developed empyema.

In our series, the 73 patients who were thoracotomized solely for the removal of a foreign body all recovered uneventfully and returned to duty.



A. *B.*

Fig. 5.—*A*, Chest film showing organized right hemothorax. *B*, Roentgenogram taken following decortication.

In view of the good results obtained by leaving the foreign body, if at all possible, undisturbed for two to three weeks, we feel that nothing is gained by early thoracotomy for removal of foreign bodies. Delaying operation until local reaction has subsided obviates considerable unnecessary bleeding at operation and makes location of the foreign body easier. Also the patient is usually in much better condition to stand the operation.

MEDIASTINAL WOUNDS

Forty-two, or 2 per cent, of our patients suffered mediastinal wounds with retention of foreign bodies. The small number of these cases admitted to this hospital is probably accounted for by the high initial mortality of this type of injury. Twenty-two of these were in the pericardium with effusion, sixteen were in the mediastinum, and four were in the heart muscle.

The cases with pericardial effusion had very small metallic foreign bodies in or about the pericardium. The effusion usually developed suddenly, sometimes one to six weeks after injury, at which time the patient experienced severe precardial pain, rise in temperature, tachycardia and shortness of breath. The heart shadow was enlarged on roentgenogram and the electrocardiogram showed pericardial changes. These patients were observed very carefully with frequent roentgenograms, electrocardiographs, and physical examinations. Most of these patients had pericardiocenteses. Some required only one and some as many as ten. In most of these cases pyogenic organisms were obtained from culture of the fluid removed at the first or second aspiration. Sensitivity tests were done routinely and the chemotherapy of choice was administered both systemically and locally. Treatment was continued until the roentgenographic, physical, and electrocardiographic examinations were normal. All of these patients recovered and were evacuated to the Zone of Interior.

Sixteen patients had foreign bodies in the mediastinum. All of these were removed through a thoracotomy. Four patients had mediastinal abscesses about the foreign bodies. These were débrided and the abscess cavity left open into the pleural space which was drained in the routine manner. Ten of these patients returned to duty, and the remaining six were evacuated to the Zone of Interior.

Four of these patients had bullets of various caliber in the myocardium. In none of these cases did the bullet completely perforate the heart wall. The bullets were removed through a left thoracotomy. Prior to removal, several U-shaped sutures of heavy silk were placed around the missile to control any bleeding which might occur and to reinforce the damaged heart wall. These were tightened and tied when the missile was removed. All of these patients recovered and were sent to the Zone of Interior.

Except for the ten patients who went to duty in this command, all patients with heart, mediastinal, and pericardial injuries were sent to the Zone of Interior for duty because it was not felt advisable to subject them to the rigors of combat duty.

One patient, who had a small metallic foreign body in the myocardium, succumbed to cardiac tamponade twelve hours after admission before operation could be performed.

One thoracotomy was performed to remove a partial denture which was lodged in the lower third of the esophagus. The patient had swallowed it when he was blown from his foxhole by artillery fire. He made an uneventful recovery and returned to duty.

Another case of interest is one in which a 22-caliber bullet perforated the left upper chest and superior mediastinum and entered the aorta. The right leg became gangrenous twelve days after injury and was amputated upon admission to this hospital. The bullet was found in the lower third of the femoral artery.

Fig. 6.—*A*, Chest film showing partially collapsed right lung with hydropneumothorax which subsequently became infected. *B*, Lateral film of same patient. *C*, Roentgenogram taken following decortication.

PNEUMONITIS AND ATELECTASIS

Two hundred sixty-one, or 17 per cent, of our patients had pneumonitis and/or atelectasis. This is primarily a diagnosis resulting from clinical and roentgenographic examination. There is a decrease in breath sounds over the area of the lung involved with slight dullness to percussion. Occasionally moist râles will be present. Roentgenogram reveals an area of increased density, not conforming to any segmental pattern and indistinguishable from a patch of consolidation. There was evidence of intraparenchymal hemorrhage, and invariably the center of density represented the passage of a perforating missile, a retained foreign body, or lung underlying fractured ribs. Treatment of this condition consisted of parenteral administration of antibiotics, frequent coughing, and ambulation, if the patient's general condition permitted. Retained foreign bodies were treated as has already been described.

In atelectasis, bronchoscopy has been the treatment of choice. The pneumonitis generally has cleared under the above treatment in within about three weeks.

PNEUMOTHORAX

Twenty-three patients in this series were admitted with pneumothorax alone. Treatment consisted of removal of air by needle aspiration and checking intrapleural pressures initially and before withdrawing the needle. Following each thoracentesis, 300,000 units of penicillin were instilled. In six instances, the lung failed to expand on this treatment and it was necessary to perform a closed thoracotomy drainage with an intercostal catheter with suction in an attempt to accomplish expansion.

No cases of tension pneumothorax were seen.

LUNG ABSCESS

Nine patients were admited with lung abscesses. Three followed crushing injuries to the chest which were sustained in jeep and truck accidents. Six followed penetrating or perforating wounds of the chest. These were treated by pulmonary resection, six by partial lobectomy and three by lobectomy. Partial thoracoplasties were performed on two patients to obliterate the space left by upper lobectomies. All patients recovered uneventfully, five returned to duty, and four were sent to the Zone of Interior because of other injuries.

RIB FRACTURES

Three hundred fifty-four patients had fractured ribs. Most of these accompanied perforating or penetrating wounds, but 42 were the results of crushing injuries to the chest. The majority were comminuted fractures with bone fragments often driven into the pleural space and lung parenchyma. Many of these were removed at thoracotomy.

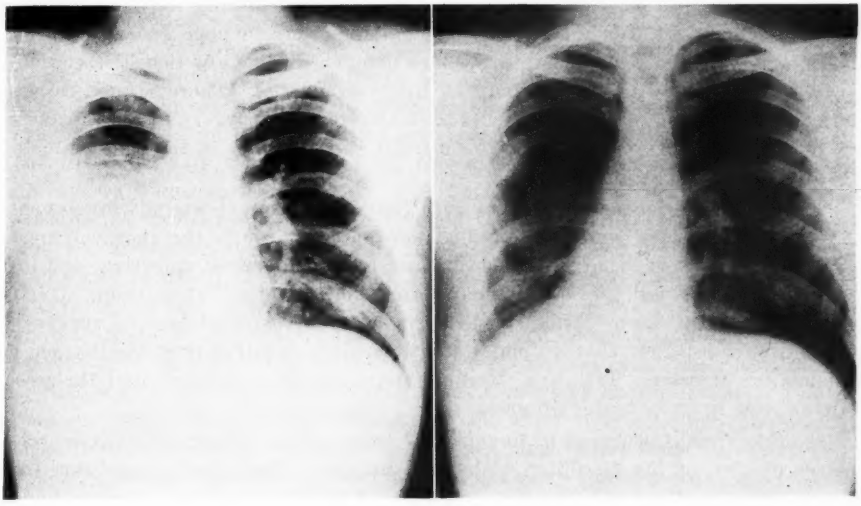
One of the most frequent complications was hydropneumothorax. In several instances, the lung was successfully re-expanded by thoracentesis only to collapse again. On closer roentgenographic examination, a bone fragment

or fragments were seen to project into the chest and would puncture the lung each time it re-expanded. In these cases, segments of the fractured ribs were removed and the edges trimmed. The lung then re-expanded and remained so.

When more than two ribs in one hemithorax were fractured, they were immobilized in the usual manner with adhesive tape.

THORACOABDOMINAL WOUNDS

One hundred eight patients suffered wounds to the diaphragm. These injuries were repaired at the time of thoracotomy. The wound was débrided, the edges of the diaphragm trimmed and approximated with interrupted sutures of 00 silk. Those patients who suffered damage to the diaphragm only in conjunction with the chest wound were usually returned to duty.



A. *B.*

Fig. 7.—*A*, Chest film showing organized left hemothorax. *B*, Roentgenogram taken after decortication.

In the event the wound was on the right side and there was also liver damage, the liver wound was débrided and cleaned at the same time. If there was infection present, the liver was drained with a Penrose drain which was exteriorized laterally below the diaphragm. Also foreign bodies, if present, were removed.

In two cases with perforating wounds of the left lower chest and upper abdomen, the patients were admitted with the stomach, spleen, and colon in the left chest. The lung was completely collapsed, and the mediastinum was shifted to the right. In both cases the stomach was perforated several times. Thoracotomy was performed, the stomach was repaired, the abdominal contents were returned to their normal positions, and the diaphragm was sutured. Both patients made uneventful recoveries and returned to duty.

The following chart shows the extent of abdominal wounding in combination with thoracic wounds encountered in this hospital.

Liver	116
Spleen	60
Large intestine with colostomy	44
Small intestine	10
Stomach	32
Kidney	20

The majority of the patients with spleen injuries underwent splenectomies in forward areas and were sent here for repair of their chest wounds. Generally, in those cases in which the patients suffered only spleen injuries, we carried out definitive chest surgery and they were returned to duty.

Patients with serious liver infections, colostomies, nephrectomies, multiple intestinal perforations, with or without resection, etc., usually were evacuated to the Zone of Interior. Most of these patients were in poor general condition, and only the temporizing procedure of open drainage with rib resection was carried out so that they could be safely evacuated. There seemed to be no point in subjecting these patients to definitive chest surgery in the theater, since few of them would be able to return to duty because of their abdominal wounds.

In our experience, many cases with thoraco-abdominal wounds involving the upper abdomen could be handled adequately through the thoracotomy. The exposure is good, often better than with the abdominal approach, and it obviates the necessity of an abdominal or thoracoabdominal incision. It is our feeling that those patients who need more extensive abdominal surgery should have separate thoracotomies and laparotomies rather than the thoracoabdominal incision. Infection, if it develops, is more localized, and the patients seem to make better progress.

Three deaths occurred in this group. One patient died seventy-two hours after closure of his disrupted abdominal incision. Two deaths were due to generalized peritonitis in patients with numerous intestinal perforations and extensive liver damage.

NERVE INJURIES

One hundred ninety-seven of our patients also had nerve injuries. Of these, 97 were peripheral nerve injuries, 86 were paraplegics, and 14 were intracranial.

The general principles of treatment were the same for handling all these types of injuries. However, there was considerable difficulty in adequately aspirating or draining the pleural fluid in the treatment of paraplegics because of the horizontal position required on the Stryker frame. In addition, the ability to cough was usually lessened because of the paralysis of the abdominal musculature and the position of the patient.

All of these patients received only palliative treatment, thoracentesis, or thoracotomy drainage with rib resection and were evacuated to the Zone of Interior.

One death occurred in this group. A paraplegic with a chest wound showed signs of increasing intracranial pressure and died following decompression by burr holes.

ORTHOPEDIC INJURIES

Four hundred eight patients had serious orthopedic problems. Most of them had fractures of the extremities. The majority of these patients received only temporary treatment and were evacuated to the Zone of Interior. However, some recovered from both their chest and orthopedic injuries and returned to limited duty in the theater.

SUMMARY

During the Korean conflict, between July, 1950, and January, 1952, 1,535 chest casualties were admitted to Tokyo Army Hospital. Of these, 66 per cent had penetrating wounds, 32 per cent had perforating wounds, and 2 per cent were crushing injuries of the chest.

Nine hundred fifty-two patients developed hemothorax; 74 per cent of these remained sterile, and 26 per cent became infected. Sixty-eight per cent of these patients were treated by thoracentesis and antibiotics alone, and recovered and returned to duty. One hundred fifty-two decortications were performed without a death. Eighty-eight per cent of these patients were considered as having good results and returned to duty, 6.5 per cent had fair results and returned to limited duty, and 5.5 per cent were considered to have poor results and were sent to the Zone of Interior for further treatment. Ninety-two per cent of the patients who required decortication had closed intercostal tubes inserted in Korea. In view of the fact that 79 per cent of the patients with hemothorax recovered when treated by thoracenteses and antibiotics, we feel that thoracentesis is the best early treatment for hemothorax and that, if this more conservative treatment had been carried out more frequently instead of closed thoracotomy drainage, perhaps decortication could have been avoided in some cases.

One hundred four patients had foreign bodies removed from their chests. Seventy-three thoracotomies for removal of foreign bodies were performed. Twenty of these patients also had partial lobectomies. All recovered uneventfully and returned to duty. Thirty-one patients had foreign bodies removed at decortication. All 104 patients returned to duty. Twenty-six patients were thoracotomized in forward areas for removal of foreign bodies. These had either fair or poor results because of increased morbidity and diminished pulmonary function. When compared with the results obtained by delayed removal, it would seem that it is best to leave the foreign body undisturbed, if possible, for later removal.

Nine patients who had lung abscesses were treated by lobectomy or partial lobectomy and recovered and returned to duty.

One hundred eight patients suffered injuries to the diaphragm. These were repaired at thoracotomy. One hundred seventy-four patients had thoracoabdominal wounds. In general, those patients with serious liver infections,

colostomies, multiple intestinal perforations, etc., were treated conservatively by open thoracotomy drainage with rib resection so that they might be safely evacuated to the Zone of Interior.

The 197 patients with serious nerve injuries were treated with thoracentesis or rib resection and thoracotomy drainage and then evacuated to the Zone of Interior. The 408 orthopedic injuries were treated much in the same manner.

Our operative mortality at this hospital was 0 per cent. The over-all mortality was 0.4 per cent.

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DISCUSSION ON "THE CARE OF THORACIC AND THORACOABDOMINAL WOUNDS IN THE COMBAT ZONE IN KOREA," BY MAJOR EDWARD ERNEST ROCKEY; AND "WAR WOUNDS OF THE CHEST: EXPERIENCES WITH 1535 KOREAN CASUALTIES IN AN ARMY HOSPITAL OVERSEAS," BY MAJOR A. R. VALLE

DR. HOWARD E. SNYDER, Winfield, Kan.—I think Dr. Berry's fine address clarified some of the statistics you have just heard, but it might be well to call attention to

some of our deficiencies in Korea. You will note that in this series of chest cases the incidence of empyema has again risen to 25 or 26 per cent. That is probably just as much our fault as tax-conscious citizens as the fault of any individual surgeon. Dr. Berry has pointed out that the work was done with these mash units, one per division. They did not only the job they were supposed to do, the care of first priority casualties, but cared for all the rest of the casualties as well. They had little time for the so-called minor wounds. The terrific casualty loads in September and December of the first year of the war were not expected. There were just too many to be properly taken care of by the hospitals available. That is one reason for the rise in the empyema rate. There are other reasons and, again, we ourselves may be deficient. The Army did not have a sufficient number of specialists, fully trained men. The men who were there did a good job, did the best they could with their qualifications and with the time they had available. But there were very few men with Board qualifications in general surgery and, probably, none with qualifications in chest surgery in Korea in the early months of the war. We certainly are in part responsible for that, because the Army is limited now in the men they can call. Class I and Class II in the doctor draft classification do not provide many specialists.

I was rather surprised at Major Rockey's conclusion that an abdominal incision was the best in handling a wound of the diaphragm, with certain exceptions. I think in World War II we formed the other conclusion; most of us who liked to do chest surgery (and almost every surgeon did before the war was over) would much rather approach a diaphragmatic wound from the chest, and we preferred the conventional posterolateral incision in most cases unless the wound was such as to indicate an anterior incision. We did not like to do the vertical incision through the cartilages except in certain specific instances. There were those of us who did like the combined thoracoabodminal incision, in which a small extension of the thoracotomy wound into the anterior abdominal wal. might permit all needed exploration in the abdomen. There were others who, as Major Valle expressed himself in the second paper, preferred separate incisions. I think it is preferable to use the thoracotomy incision and close the diaphragm before the abdomen is opened, because a diaphragmatic wound, unsutured, may become a sucking wound as soon as the abdomen is opened, with disastrous results. If the diaphragm as well as the chest wall is repaired before the abdomen is opened that sort of catastrophe can be avoided.

DR. LAWRENCE M. SHEFTS, San Antonio.—I should like to congratulate the essayists on the compilation of their work. I, as well as many others here, know full well the difficulties of trying to send a report out of a combat area, particularly in the forward zone. They are certainly to be congratulated for their evaluation of results, for when one considers that anywhere from 28 to 46 per cent of this type of wound may have major associated wounds, the evaluation of results of the management of any one type of wound in these patients is particularly difficult.

I would like to make it very clear in these informal remarks that if I sound at all critical, in case the Surgeon-General should accidentally read this discussion, I would like him to know that I could not do any better. I have no desire whatsoever to end up in Korea.

There are a few points on which I feel certain we are all in agreement. The first is that we learned in World War II that the resection of a damaged lung, even though it may appear to be in bad shape with a hematoma and lacerations, is very seldom necessary; if one leaves it alone and provides adequate decompression and drainage, it is perfectly amazing how much recovery of tissue will result.

Next, concerning the involvement of the left diaphragm in relation to indications for thoracotomy, I would not argue in the slightest except for personal preference and ease of technique as to approach, but I think it is dangerous to let any sentence stand concerning the statement that suspicion of or injury to the left diaphragm would not constitute an absolute indication for exploratory thoracotomy. Regardless of how it may

be qualified, such a statement quoted out of text would in my experience be quite in error. Someone will assuredly quote it out of text without the explanatory qualifications, and trouble would undoubtedly result. I feel there is no argument if someone wants to operate through the abdomen and handle the involved diaphragm or through the chest or through a combined approach. That is a matter of personal experience, but I think it is dangerous to have this get into print without a careful explanation, because involvement of or suspicion of involvement of the left diaphragm is an absolute indication for exploration, in my experience.

On my return from the Mediterranean Theater in World War II, I became interested in the mortality and morbidity of thoracoabdominal wounds in civilian hospitals, and I became aware of the fact that the mortality was twice what we had in field hospitals. The majority of factors involved are on the side of a lower civilian mortality. The time interval between wounding and definitive surgery may average as high as eleven or twelve hours in war wounds, whereas it is a matter of minutes or a few hours in civilian wounds. There is not the gross contamination in civilian wounds that is constantly experienced in war wounds. Furthermore, it is relatively rare to have as high a percentage of major associated wounds in civilian practice as one has in war wounds.

On the other hand, in war time one is operating on young, previously healthy individuals, and it is also true that because of the promptness with which civilian wounds are carried to the hospitals, more mortally wounded might therefore be seen than would arrive at field hospitals. However, these last two factors do not negate the previous ones, and when one considers that the surgery of trauma is simplicity itself—one only stops a hemorrhage, cuts something out, exteriorizes it, or sews it up—the cause of the difference in mortality must therefore be searched for elsewhere.

I think that the big difference lies in one particular factor, that is, preoperative management or, what should be better termed, the resuscitative phase. I do not believe that the information we have obtained concerning the importance of this phase has been carried over sufficiently into civilian life. The idea of spending two or three hours resuscitating a patient before operating, and not taking him directly to the operating room simply because he has a sucking wound, is not well enough known. Furthermore, many cases, if properly resuscitated, will not require surgery, for one can evaluate only the necessity for surgery after one notes how a patient reacts to adequate resuscitative measures, and I think one need only mention that a patient properly resuscitated will stand surgical interference far better, even if in some cases the surgical interference is not warranted. I must admit honestly and many of you men who did similar work in the Second World War, if you are honest with yourselves, will admit to plenty of cases that you opened, and after you got in you wondered what you were doing in there. Personally, that experience decreased from Sicily to Southern Italy to Northern Italy, etc., for me. As I saw more and more cases, I was actually operating fewer of them but spending more and more time in the shock tent resuscitating the patients. After they have been resuscitated properly, then and only then can you properly evaluate them. Surgical insults that occur otherwise are inexcusable, and certainly they are inexcusable in civilian life where one does not have the pressure of 20 more cases waiting in the shock tent.

DR. FREDERICK R. HARPER, Denver.—I wanted to discuss these papers only to agree with the authors. During the Second World War, I was in the South Pacific in a general hospital. I thought we had a rather unique experience in that we received two groups of patients. One group came from Saipan and Peliliu. Those were campaigns where the medical corps was hard pressed and many of the wounded were taken directly to the beaches and put on hospital ships and sent down to us. The Navy surgeons in those hospital ships were very hard pressed so they did very little for the ordinary thoracic wound. The other group of patients came down from Leyte, through field hospitals, evacuation hospitals, and so on. These patients had been treated before they got to us. Tubes had been used in most cases. There was a very marked difference between the two groups; the group that came down in Navy ships, who had had practically no treat-

ment, did much better than the group that came down through the hospitals and had tubes and drainage. There were fewer decortications necessary and fewer complications in the untreated group. We could not help noting that patients who had needle aspiration only did much better than those who had tube drainage. I see no indication for tube drainage unless you are dealing with a positive pressure pneumothorax; otherwise needle aspiration is adequate.

The indications for immediate open theroacotomy are few: (1) large open sucking wounds, (2) bleeding which cannot be controlled because it is coming from a major vessel, (3) pneumothorax which cannot be controlled because it is due to an open bronchus, (4) cardiac tamponade, (5) some patients with flail chest, I think, can be handled better by open thoracotomy, and (6) the thoracoabdominal wounds. My only point of disagreement with the authors with regard to thoracoabdominal wounds, if I understood correctly, is that I believe many patients who have thoracoabdominal wounds should have the thoracotomy done first or at the same time, even though a thoracotomy would otherwise not be necessary. If you do not stabilize the cardiorespiratory system before you open the abdomen, I think you are inviting difficulties.

DR. LAURENCE MISCALL, New York.—The experience from which I speak is that seen in a large thoracic center in the rear area in England. Here Dr. Harrison and I had an excellent opportunity to see the results of treatment that was carried out in all the prior stations, including station and general hospitals in England. I agree certainly with the statement that most hemothoraces can be treated effectively by aspiration and other conservative measures. In a survey of over 200 patients, we found that at least 70 per cent responded favorably to these methods. However, in the hemothorax or hemopneumothorax which could not be controlled readily by repeated aspirations, good results followed closed drainage which was maintained long enough to permit expansion of the lung. We found poor results when the drainage was ineffective or used for too short a time. These individuals had considerable trouble with clotting and infection during or after evacuation to the rear. This is a sound basis for questioning the advisability of the early removal of the tubes after thoracic exploration in the forward area.

In thoracoabdominal wounds we found that the patients who had difficulty had one or more of these therapeutic deficiencies; the abdomen and chest had not been securely separated by complete repair of the diaphragmatic defect; the chest had not been adequately drained; exploration had been inadequate; defects below the diaphragm had been neglected frequently. This was particularly true on the right side where unsuspected damage to the liver had caused many patients to return to the hospital with pleural and/or subphrenic infection. These facts prompted us to explore adequately both above and below the diaphragm as a routine.

The other point that might be suggested to the individuals in Korea concerns the clotted hemothorax with unavoidable delay in treatment. The use of streptokinase and streptodornase immediately after operative decortication has been quite satisfactory in our hands.

DR. GEORGE N. J. SOMMER, Jr., Trenton, N. J.—Chiefly, I wish to agree with Dr. Miscall. Working in the quiet atmosphere of a thoracic surgery center in England, I made an effort through examination of the patients and their records to decide whether repeated aspiration or tube drainage was the best method of preventing clotted hemothorax. I reached no clear-cut opinion. Furthermore, I have seen patients in civilian life who had extensive clotted hemothoraces within twenty-four hours after being stabbed. I do not believe that drainage by intercostal tubes would have prevented clotting in these patients, nor would aspiration, since the clotting must have occurred almost immediately.

Furthermore, we must allow for the judgment of those who are treating patients near the front lines. Certainly the busy surgeon with many seriously wounded men under his care is going to employ intercostal drainage after operation rather than repeated

aspiration simply because he may not have time for the latter. For myself, I wish to state that I feel intercostal drainage is properly used following operations for injuries to the chest and lungs.

Experience in the thoracic center did show, however, that the best results in the treatment of thoracic injuries were obtained by well-trained surgeons. The caliber of treatment of patients admitted to the center depended upon the skill and experience of the men giving the primary treatment near the front lines.

The suggestion that an upper abdominal incision be carried up over the anterior thorax with transverse division of ribs or cartilages to afford exposure of the intrathoracic contents is a poor one. The division of multiple ribs in such a manner will provide an immediately unstable thoracic wall with the increased hazard of atelectasis and paradoxical movement. To wire such ribs to avoid the unstable thoracic wall will undesirably prolong the operation time. Furthermore, late thoracic deformity will occur unless very meticulous care is used to prevent it. Even the best of late care will not always prevent deformity with multiple rib fractures or division. If thoracic exploration is required after abdominal operation, the incision could be prolonged upward in the standard method through an interspace or another incision could be made.

DR. WARRINER WOODRUFF, Saranac Lake, N. Y.—As I listened to these two papers, it seemed to me that they present experiences of two distinct and separate types. One is that of a surgeon in the forward area who is extremely hard pressed with many casualties and insufficient time to give to them; and the second paper reflects the problem as seen in a rear-area hospital in Japan. I think the figures show the difference. My experience was limited to two campaigns: Iwo Jima and Okinawa. I was on Guam during both campaigns. From Iwo Jima many of our patients were flown in 650 miles, and we had one boy admitted ten hours after he had been hit. In general, casualties from Iwo Jima were seen earlier than those from Okinawa, because policy of evacuation was changed and it became practice not to transport chest cases by air, so we received almost no casualties from Okinawa for primary treatment. The reason I mention that is this: I know that our incidence of empyemas increased, the longer the interval between wounding and the time we saw them. I don't know what the experience of others has been, but it seems to me that in the long run it may be better to lose an occasional chest case by air transport than to take the hazards of the necessary delay of water transport. If I have understood these figures correctly, the average time before admission to the hospital in Japan was six days, but on some patients there was a delay of up to thirty days. I wonder if complications were not higher in this latter group. Certainly we found it so.

There is just one thing I should like to say, if we are helpful to Dr. Rockey. There is one patient whom he cited who had a crushing injury of the chest with bilateral pulmonary involvement, who died very soon postoperatively, coughing and raising blood. As he stated, they were unable to keep the airways free despite all attempts, including bronchoscopy. All right—in a forward area such as that, you just do not have time to do the amount of tracheal aspiration that should be done, and I wonder if it would not be worth while to call Dr. Rockey's attention to the possibility of tracheotomy on some of these severe cases, so that the nurses may keep the secretions aspirated regardless of the patient's condition.

DR. MARK H. WILLIAMS, Binghamton, N. Y.—I want to say one word about the management of hemothorax. It is well established that needle aspiration is usually an effectual measure, but if aspiration is incompletely done, pleural complications necessitating drainage or decortication may occur. A simple and effectual way of performing thorough aspiration has been helpful to me, and I think it should be applicable to military practice. This is actually a minor operating room procedure which requires a strong source of suction. One positions the patient in the supine position on the operating table, elevating the head and shoulders to about 45 degrees and then introduces a trocar through the first or second interspace. The Coryllos thoroscope trocar, which permits the introduction of the 16-gauge urethral catheter, has been used. The catheter will pass back-

ward and then down to the diaphragm, and by moving it back and forth a thorough aspiration, including the evacuation of clots, can be done. If the catheter becomes occluded it is withdrawn and cleaned. It may be helpful to introduce saline solution from time to time when clotted blood is present. Within five or ten minutes one can aspirate practically all the blood including clots. The catheter is then withdrawn slowly removing the air and re-expanding the lung. A simple stitch completes the procedure. This method of aspiration has been useful in patients having hemopneumothorax associated with multiple rib fractures, and in clotted hemothorax following resection. The method is time-saving as well as more complete, when compared with needle aspiration, and should be helpful in any large hemothorax, particularly if clotting has occurred.

DR. IRVING A. SAROT, New York.—I would like to speak from the point of view of one who, during the entire Northern European campaign, was in a forward unit. There were three small points which in my experience saved more patients' lives than almost anything else we were able to accomplish. First of all, in Normandy we had a great deal of blood, and for a long time I did not realize that the men in the shock wards, in the shock tents were overloading patients with tension pneumothorax, and I followed Dr. Shefts' experience and began to spend more and more time in the shock tents and less and less time operating. I found I had to caution the men in the shock tents against overloading these patients with blood. A patient would be brought in in shock and would promptly be given blood, even though his shocklike picture was due to tension pneumothorax, and I found that pulmonary edema would supervene and kill some of these patients. So we instituted the regime of early decompression first by a needle through a cork, using a finger cot. We found that underwater drainage was relatively unsatisfactory because it was bulky, it immobilized the patient, and because the nurses had to spend too much time watching it. Finally, routinely almost, in the severely injured patients—and we had a big backlog—we put a small catheter through a puncture and put a finger cot on it and let the patient decompress himself while we gave blood and then cleared the secretions and prepared him for surgery if it were necessary.

The second important thing we found was that we had to direct the evacuation of the patient. A patient with a tube in his chest, or one who had been aspirated and then through the pressure of new casualties had to be evacuated before we were quite ready for this stage, had to be directed in special ambulance toward a general hospital or center where we knew he would not be lost in the shuffle of evacuation. By these two steps I think we saved more patients, perhaps, than by operating on them.

MAJOR VALLE (Closing).—I wish to thank the discussors for their interesting comments. Dr. Snyder well knows the situation here since he visited us at one of our busiest times.

I would like to mention that Korea is one of the countries which uses "night soil" or human excrement for fertilizer, and the grossly contaminated soil may have some influence on the incidence of empyema and wound infection.

It is true that we lacked trained chest surgeons in Korea, and I feel that this lack of trained personnel is the reason so many thoracotomies and thoractomy drainages and even resections were done in forward areas. I agree with Dr. Shefts that conservative, judicious treatment in forward areas of the majority of chest wounds will save many patients from decortication and/or resection, and certainly will diminish morbidity.

I am interested to note that Dr. Harper had much the same experience as we have had at Tokyo Army Hospital, i.e., the patients who received little or no treatment before reaching a general hospital did better than those who had thoracotomies or thoracotomy drainage.

Regarding Dr. Sommer's remark that busy surgeons do not have time for thoracenteses, I would like to say that several thoracenteses can be done in the time it takes to do one closed thoracotomy drainage. Also, thoracotomy drainage requires more elaborate equipment and looking after it consumes a considerable amount of the nurses' time.

Also, it often gives a false sense of security in that drainage is instituted and then forgotten about, because of the feeling that the problem has been solved. However, it is later that the consequences must be dealt with.

Regarding Dr. Woodruff's comment about the average time elapsed between injury and date of arrival at the general hospital of six to thirty days, respectively, in our latter group the treatment received on the hospital ship paralleled that received in the general hospital.

MAJOR ROCKEY.—I would like to express my thanks to Dr. Snyder, Dr. Shefts, Dr. Harper, Dr. Miscall, Dr. Sommer, Dr. Woodruff, Dr. Williams, and Dr. Sarot for their very valuable remarks which were of great help in re-emphasizing many of the important points of this presentation.

As Dr. Woodruff very well stated, the experiences in the forward area are distinctly different from the ones in the rear. The more thorough and understanding care is given at a Mobile Army Surgical Hospital level to these patients, the less complications requiring elective surgical interventions are faced in Japan. As Dr. Snyder indicated, this can be accomplished only if more trained surgeons are available in the combat zone, or perhaps the men in such units could have intensive on-the-spot training in the early and intelligent management of thoracic and thoracoabdominal injuries.

The reason for the difference in the statistics between the forward area and the cases handled in Japan is obvious. When a Mobile Army Surgical Hospital is quite near to the front line with the helicopters, patients reach us who would otherwise be dead on arrival. As a matter of fact, a number of them were dead by the time we put them on the operating table for resuscitation purposes, and we included them among our operated cases. Most of the other cases were of great risk, and this is the reason they were operated on in a forward unit.

It is a great regret to me that I was not able to be present at the meeting of this Association, particularly since, on one of the main issues of my presentation, the management of diaphragmatic perforations, I could have elaborated in greater detail. In response to the remarks of Drs. Snyder, Shefts, and Harper, I wish to say that it is not a matter of personal preference that I suggest laparotomy for the management of thoracoabdominal wounds, but it is the question of doing the least number of and the least extensive procedures which will provide an opportunity to re-establish as normal cardiorespiratory physiology as possible as well as correction of the intra-abdominal damage. This choice is not a question of taking the attitude of the general surgeon who is, perhaps, not too well versed in the various thoracic approaches, since I am primarily a thoracic surgeon. In view of the fact that the diaphragmatic tear is taken care of as a first step in the operation after the abdomen is opened, its sucking effect is eliminated, the pleural space is evacuated, and the lung is fully expanded. This can be accomplished with ease and without danger since the patient is handled under endotracheal anesthesia. Under these conditions, no ill effects of this procedure were observed. The majority of the thoracoabdominal injuries do not require exploration of the chest, just as the majority of the chest injuries can be taken care of by aspiration only. In other words, we are saving a thoracotomy or the thoracotomy part of the abdominothoracic exploration without sacrificing complete evacuation of the pleural space and full lung re-expansion prior to the diaphragmatic closure. One should not hesitate to extend the laparotomy incision into an abdominothoracic one if difficulties are encountered either in the management of the intrathoracic phase of the injury or in the closure of the diaphragmatic perforation. In my experience, in the majority of the cases, such extension was not necessary. Had I handled these patients by thoracotomy first, many of the patients who were submitted only to laparotomy would have been submitted to thoracotomy as well or to combined thoracoabdominal exploration without accomplishing more than was accomplished by the method I propose. Among the casualties, there were several cases of perforation of both leaves of the diaphragm, which were successfully handled by laparotomy, evacuation of the pleural spaces through the diaphragmatic tears, full lung re-expansion prior to the

closure of the diaphragmatic perforations followed by correction of the intra-abdominal injuries. Through the laparotomy, all three body cavities were adequately taken care of. I wonder if the believers in thoracotomy for diaphragmatic perforations would have submitted such a patient to bilateral thoracotomy plus a laparotomy. If not, then we are in agreement in principle, at least. It cannot be stressed sufficiently how important it is to follow the technique of the closure of the diaphragm and complete evacuation of the pleural space as discussed in detail in the presentation. Complete evacuation of the pleural space and full lung re-expansion must be accomplished in order to avoid subsequent pleural complications.

I wish to repeat that thoracotomy alone, in cases of thoracoabdominal injuries, is dangerous, because the survey of the intra-abdominal organs cannot be complete through the diaphragm. By this method, cases with missed bowel perforations are known to many of us. The choice of procedure, in my estimation, is the one which is the least extensive and accomplishes the most; that is, laparotomy with extension of the wound into the chest only if the combined injuries cannot be handled successfully by laparotomy alone, which is the exception rather than the rule. In other words, I do not recommend thoracotomy for diaphragmatic perforation. If the chest needs to be entered, it is done only as an extension of the abdominal incision. This leads me back to my original statement that perforation of the diaphragm is not an indication for thoracotomy.

It is of great value that Dr. Shefts emphasized the very rare need for resection of damaged lung tissue. In this series, this was necessary only as an exception and, even in these few cases, consisted of segmental or subsegmental removal of devitalized tissue hardly attached to the rest of the lung.

Dr. Woodruff stressed the value of tracheotomy for thoracic injuries. This is a very helpful procedure in well-selected cases, namely, the ones with considerable lung damage with a great deal of expectoration of blood and mucus, for the purpose of making the nursing care easier and more effective in keeping the tracheobronchial tree clear. As a matter of fact, the very same patient quoted by Dr. Woodruff had a tracheotomy. His death was inevitable as the autopsy findings indicated and as was described in the presentation.

The remarks of Dr. Williams are of great interest to me, since they substantiate a basic principle applied in the management of the sucking wounds in this series, namely, early and complete evacuation of the pleural space by a catheter through the débrided chest opening and removal of the catheter prior to the closure of the chest wall wound up to skin level. On patients without sucking wounds, in a combat zone, tube aspiration is not feasible except when the casualty load is not heavy.

I feel greatly indebted to Drs. Berry, Graham, and Samson, who arranged the presentation of this paper in absentia on a few days' notice, and to Dr. Wylie for being so kind as to accept the burden of reading the paper.

THE REPAIR OF TRACHEAL DEFECTS WITH FASCIA AND TANTALUM MESH: AN EXPERIMENTAL STUDY*

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UNTIL recent years surgical treatment of the trachea has been concerned primarily with the sequelae of infections, such as diphtheria, repair after trauma, tracheotomy and, infrequently, with neoplasms. One of the earliest reports concerning a bolder surgical attack on the trachea is that of Burket in 1918. In this report he summarized experimental and clinical reports of end-to-end anastomosis, resection of annular segments, and described transplantation of various tissues into surgically created defects of the trachea. Recent interest in the repair of tracheal defects has been concerned principally with techniques, which may be used after removal of neoplasms infiltrating the trachea either primarily or secondarily.

In animals, Taffel and Daniel have reported the repair of small defects created by excision of portions of the cervical trachea and of closure of the end of a main bronchus with autogenous fascia. They concluded that excellent healing took place in such grafts. Fascia has been reinforced by a spirally coiled wire[1] or woven wire strands, steel wire mesh, and tantalum mesh with varying degrees of success.[2, 9, 17] Dermal grafts reinforced with wire have been used.[10] Several types of inlying tube prostheses have been used successfully in the laboratory and clinically in at least one case.[4, 6, 11, 13] The bifurcation of the trachea of the dog has been successfully resected by several different methods[6, 7, 9, 12] and, more recently, the feasibility of implantation of a bronchus into tracheal windows has been under investigation.[15, 16] Homografts of tracheal segments have only rarely given good results, and are ordinarily observed to undergo necrosis with resorption of cartilaginous elements.[5, 14] Davies and co-workers reported that they obtained survival of cartilage homografts when they used an inlying tube support for the graft. The condition of the cartilage after they removed the inlying tubes has not yet been reported.

Our report deals with repairs of the intrathoracic portion of the trachea of dogs and covers the use of autogenous fascia and tantalum mesh, separately and in combination. A few studies were made in which fascia was combined with autogenous cartilage either cut in the form of tracheal rings or ground finely.

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METHODS

Healthy adult mongrel dogs weighing between 10 and 22 kilograms were used. Anesthesia was obtained with ether administered through an endotracheal tube by means of an insufflation apparatus. Exposure of the trachea was effected through an incision in the right fourth intercostal space.

Group 1. Fascia.—There were sixteen animals in this group. "Windows" which included segments of two to four rings and varied in size from 1 by 1 cm. to 2 by 2.5 cm. were made in the right lateral wall of the trachea of all animals. The fascial patches were obtained from the right paravertebral muscles in most animals; rarely fascia recta was used. The patches were cut large enough so that at least 0.5 cm. would overlap the trachea around all margins of the defects. Fascia was applied by means of interrupted sutures in each corner of the patch followed by a continuous suture which went through cartilage rings and fascia. The suture material was 000 chromic catgut. If these patches were applied without too much tension, they were airtight.

Microscopic study of sections of the graft and adjacent trachea stained with hematoxylin and eosin was carried out at intervals of two weeks to six months after operation.

Group 2. Fascia and Cartilage.—In this group there were eleven animals in which windows were made as previously described. Cut or ground cartilage was applied to the external surface of fascia grafts which were made as described for Group 1. From four animals long, narrow strips of costal cartilage were removed with a scalpel. These strips, which tended to curl like a tracheal ring, were fixed to the fascia by means of interrupted catgut sutures carefully placed through the external fibers of the fascia. One or two of these cartilage "rings" were used in each of the four animals and gave the graft area a convex outer surface.

From the other seven animals, cartilage was removed from the tips of lower ribs and ground with a chondrotome. In three animals the fragments of cartilage were applied to the fascial grafts with a piece of Gelfoam, and in four were spread on a freshly made blood and bovine thrombin* coagulum which had been applied on the external surface of the fascia grafts.

Group 3. Fascia and Tantalum.—These materials were used for a total of ten animals in which tracheal defects were made as described for Group 1.

Small Patches.—Patches of fascia were attached to one surface of a piece of tantalum mesh by catgut or cotton sutures. The edges of the mesh were carefully folded over so that sharp ends of wire did not protrude. Such patches were made of the same size and shape as the defect. In three animals, mesh lined the interior of the patch, and in four, mesh was on the exterior.†

Large Patches.—In three animals pieces of tantalum mesh large enough to lap over the normal trachea on all edges of the defect were used. After the defect in the trachea had been repaired with a patch of fascia, the tantalum mesh was placed over it and the adjoining portion of the trachea, and at-

*Bovine thrombin was diluted so that there were 100 units per cubic centimeter.

†Tantalum mesh was obtained from the Ethicon Suture Laboratories, wire was 0.003 inch in diameter and 50 gauge.

tached to the fascia by interrupted catgut sutures. Finally, the tantalum mesh was molded by pressing it against the metal endotracheal tube being used for the anesthesia.

Group 4. Tantalum Mesh With Temporary Prosthesis.—In this group there were eight animals. Large windows were removed from the trachea in two animals, and tubular resections with removal of the entire circumference of the trachea were carried out in six. We repaired these defects by placing a plastic tube prosthesis in the lumen of the trachea and covering it with tantalum mesh. Before resection was performed, the plastic tube was introduced into the trachea through a transverse incision. To seal the airway, two loosely twisted ligatures of three strands of No. 1 chromic catgut were tied around the trachea, one close to each end of the tube. Then a portion of wall of trachea or a tubular segment including seven to eleven rings was excised between these ties. The size of the remaining gap, in animals in which tubular segments were removed, was determined by the tension of four interrupted 000 cotton sutures which passed from one end of the trachea to the other over the surface of the tube. This reduced the gap to about 2 cm. A piece of tantalum mesh with folded margins which was large enough to lap over the edges of the trachea at each end was placed snugly around the exposed portion of the tube. The mesh was held in apposition to the tube by means of cotton sutures placed in the mesh which served to tighten the mesh around the trachea.

The inlying prostheses were polyethylene tubes* 6 cm. in length with a wall thickness of $\frac{1}{16}$ inch (0.16 cm.), having two sizes of lumen. One had an internal diameter of one-half inch (1.27 cm.) and another of five-eighths inch (1.59 cm.). These tubes were smooth except for three shallow encircling grooves on the exterior near one end which had been made by pressing a heated wire into this surface. The caudal ligature encircling the trachea was tightened around this grooved area to prevent the tube from being dislodged during the postoperative period. The smooth surface and shallow grooving allowed ready removal with bronchoscopic forceps within one to seven months after operation. Periodic bronchoscopic observations were made of the tube and later, after the tube had been removed, of the area of the graft. After the animals were killed, sections made of tissues carefully peeled from the tantalum mesh were studied microscopically.

Group 5. Tantalum Mesh and Fascia With Temporary Prosthesis.—These were used on four animals.

Repair of tubular defects was accomplished by a method similar to that used in Group 4 but modified as follows: (1) A sheet of autogenous fascia was wrapped around the defect to cover the exposed tube and the end-to-end sutures before the tantalum mesh was applied. (2) The fascia and tantalum were fixed to each end of the trachea by a few interrupted cotton sutures, and the tubes were withdrawn two, two and one-half, five, and five and one-half months after operation.

*Plax Corporation, Hartford, Conn.

RESULTS

Group 1. Fascia.—Grossly, all of the grafts looked much alike (Fig. 1, *a*). Histologic examination showed that the graft was covered with ciliated epithelium in two instances four to five weeks after operation, although one graft was not covered three months after operation. The grafts were flexible and slightly shrunken; a slight to moderate transverse ridge of fibrous tissue covered by epithelium protruded slightly into the lumen. In several dogs the

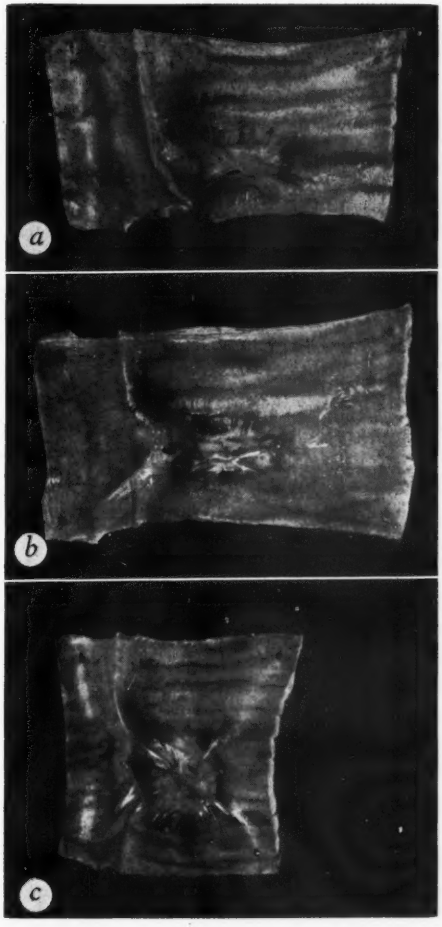

Fig. 1.—Segments of the thoracic portion of the tracheas opened to display the grafts. *a*, The defect was repaired with fascia, and the animal (Group 1) was killed two months after operation. The typical ridge is shown and a tiny ulcer is seen on the center of the graft. *b*, The trachea was repaired with fascia and a strip of cartilage, and the animal (Group 2) killed five months after operation. The graft was well healed with practically no deformity of the lumen. *c*, A large fascia and tantalum patch (Group 3) was used. Specimen obtained three and a half months after operation was well healed and had a good lumen.

normal curvature of the remnants of the cut rings had been lost, and the flattening of the wall opposite the graft which resulted from this produced some further narrowing of the lumen.

The autogenous patch of fascia appeared to have survived in all cases. The evidence for this was that the patches were well vascularized early, there was no decrease in number of cells to suggest gradual death and removal of cells, and in several grafts intact islands of fat cells were noted. The tracheal epithelium seemed to spread across the graft surface with only a minimal granulating base. In fact, epithelium was absent only over a few superficial collections of inflammatory cells or small patches of granulation tissue. In several animals in which the transverse ridge was most prominent and thick, the epithelium on the ridge was nonciliated, cuboidal, or flat. Contracture of the scar appeared to have caused decreased vascularity in the area of the ridge. In two instances tiny, persistent ulcers were found on ridges. There was virtually no regeneration of mucous glands in graft areas, and regeneration of cartilage was confined to islands too small to be apparent on gross examination and located usually near the tips of severed cartilage rings.

Group 2. Fascia and Cartilage.—In three of the four dogs in which long narrow strips of autogenous cartilage had been attached to the fascia the mucosal surfaces of the grafts had healed completely when the animals were killed three, four, and five months after operation (Fig. 1, *b*). The other animal had an area of granulation tissue which apparently covered the entire graft two months after operation. Surviving cartilage was present in two of the four grafts, and partial fibrous tissue replacement of the cartilage was noted in one of these two. No grafted cartilage could be found in the other two grafts.

Patches of fascia sloughed partly when ground cartilage had been applied with a piece of Gelfoam in three animals. In the four animals in which a thin layer of thrombin and blood coagulum had been used necrosis of the fascia was minimal. When sloughing had occurred, the grafts lacked epithelium, but in the four animals in which the thrombin and blood coagulum had been used, healing was complete, the areas were firm, and gross bits of cartilage could be seen in examinations at intervals of one, two, three, and four months after operation. Microscopic examination showed that the ground cartilage was incorporated into a fibrous network on the external surface of the fascia, and that there was little evidence of connective tissue replacement of the cartilage.

Group 3. Fascia and Tantalum.—Small Patches.—None of the three patches applied with tantalum mesh on the inside healed well, and only small portions of the mesh were infiltrated with connective tissue and covered by epithelium. Of the four patches applied with mesh on the exterior, two were completely covered with tracheal epithelium and the other two showed mesh surrounded by granulation tissue within the tracheal lumen. In these latter two animals, bronchoscopic examination showed that there had been gradual protrusion of irregular edges of mesh and loose wire ends through the fascia. These animals were killed one to four months after operation.

Large Patches.—Weekly bronchoscopic examination of grafts, made of large patches of fascia and tantalum mesh, indicated that these areas were

probably completely covered by epithelium within five to six weeks after operation. No mesh could be seen on any of these examinations, but in one animal a partial breakdown of the surface of the graft was found at the time the animals were killed three and one-half months after operation. In the other two animals the grafts were completely covered by normal ciliated tracheal epithelium which contained no mucous glands (Fig. 1, *c*). Grossly, the graft areas were firm and covered by a fairly dense fibrous tissue which encircled the tantalum. The mediastinal pleura over the tantalum was mobile and normal appearing. Microscopic study showed that there was no inflammatory reaction to the tantalum in any of this group, and there was no evidence of new-formed cartilage.

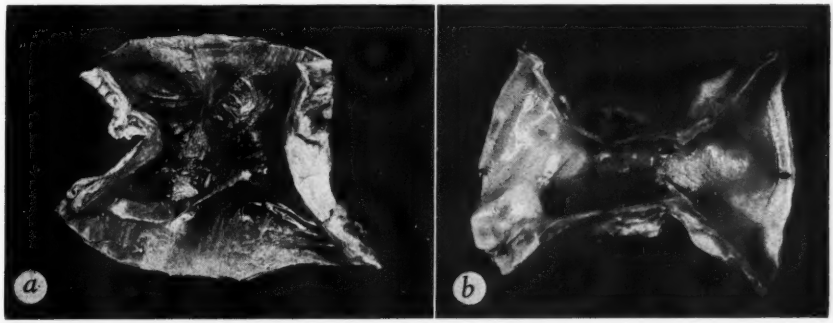

Fig. 2.—Segments of trachea and graft removed from two dogs in Group 4 in which tantalum mesh was used with a temporary tube prosthesis. *a*, Tube was removed four and a half months after operation and the dog died five months later. Tantalum mesh was not much deformed but hourglass stenosis had developed from dense scar tissue on the inner surface of the tantalum mesh. This graft contained several incomplete, new-formed cartilage rings. The central split resulted from opening specimen after fixation in formalin. *b*, Tube was removed one month after operation and the dog was killed four months later because of tracheal obstruction. The cephalic part of the graft had become detached from the trachea. The deformed tantalum mesh and the fibrous band connecting mesh with trachea are easily seen.

Group 4. Tantalum Mesh With Prosthesis.—The polyethylene tubes were fairly well tolerated by all dogs of this group. Although these dogs had short periods of vigorous coughing, they had an excellent airway as long as the tubes were in situ. On bronchoscopic examination mucoid secretion could be seen distal to the tubes in a few of the animals, but apparently all were able to get rid of this by blowing it out during expiration. Roentgenograms of the thorax which were made at intervals of one to two weeks after operation were consistently clear, and all animals gained weight between operation and the time of death.

Removal of the inlying tubes after periods of from one to seven months was followed in seven of the eight animals by progressively increasing stenosis, and at the time they were killed or died they had respiratory obstruction (Fig. 2, *a*). The length of time the tubes were in situ did not seem to be related to the degree of stenosis; for example, removal of a tube from one dog seven months after operation was followed by almost complete stenosis within one month. Survival after the tubes were removed was as follows: one and one-

half and eight months for the two animals which had undergone resection of a small portion of the trachea; and two weeks, one, four, four and one-half, and four and one-half months for five animals from which large tubular segments had been removed.

Grossly, the graft areas were firm, and the tantalum was enmeshed in connective tissue. The cephalic segment of trachea had retracted from the tantalum mesh in one dog, and a thin ring of fibrous tissue lined by epithelium was found connecting the mesh and the end of trachea (Fig. 2, *b*). The tantalum mesh was grossly deformed in this and in four other specimens, probably the result of contracture of scar tissue. The only animal in this series in which the polythene tube had become dislodged had no deformity of the mesh. We thought this tube had been expelled spontaneously, but it was found that it had shifted down to the bifurcation of the trachea and lodged there where it continued to support the graft. In the seventh animal, the tantalum was still essentially tubular, but a dense layer of fibrous tissue had developed inside the mesh beneath the epithelial lining and produced an hourglass stenosis.

More or less complete covering of these grafts with epithelium was obtained in only three of the seven animals which died or were killed. In two of these three animals, post-mortem changes were marked, and positive identification of epithelium was not possible. The other four grafts were covered by thick beds of granulation tissue. Regeneration of cartilage was found in only two grafts; in one it consisted of several thin, irregular and incomplete rings of cartilage, and in the other there were several small scattered islands of regenerated cartilage.

One dog in which a tubular resection of trachea had been performed had a completely healed graft area with a good lumen when killed sixteen months after operation. When the polythene tube was removed five and one-half months after operation, healing of the graft appeared more advanced than in any of the other dogs, and within two weeks the area seemed to be completely covered by epithelium. The graft remained unchanged from this time until the dog was killed ten months later. At post-mortem examination we found some flattening of the mesh in an anteroposterior direction. Tracheal epithelium completely covered the operative defect despite considerable irregularity of the surface (Fig. 3, *a*). The intercartilaginous tissues of two to three segments just cephalad to the graft area were stretched to two to four times normal size and produced a soft conelike narrowing of the lumen (Fig. 3, *b*). This suggests the possibility that the rigid graft may have imparted an excessive amount of strain to the adjacent tissues through the range of tracheal motion associated with breathing and coughing. This was the only specimen in our series showing such a change. The fact that the animal survived longer than any other in the group may or may not add significance to this observation.

Group 5. Tantalum Mesh and Fascia With Temporary Prosthesis.—Three of the four animals of this group died or were killed because of tracheal stenosis following removal of the tubes. In one animal the tube was in place for two and one-half months and severe stenosis developed within the next two

months after removal of the tube. In this instance the internal surface of the graft was mainly a bed of granulation tissue beneath which the fascia could be identified grossly and microscopically. There was microscopic evidence of an acute inflammatory reaction throughout the graft which was more marked than usual. In the second animal the tube was in place for two months, and then during the next four months symptoms of obstruction developed despite the bronchoscopic observation of the presence of epithelium. Post-mortem examination revealed a gap between the mesh and the cephalic portion of the trachea, a gap bridged by fibrous tissue which was not rigid enough to prevent collapse during inspiration. Approximately one-third of the graft had a new covering of epithelium surrounding the usual bed of granulation tissue.

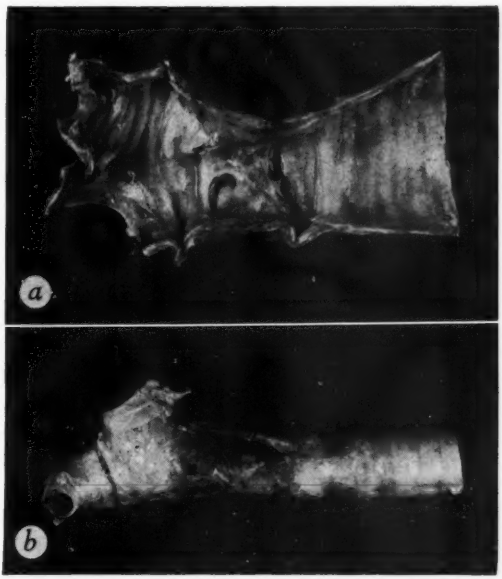

Fig. 3.—*a*, Successful graft in animal of Group 4; graft was covered by epithelium sixteen months after operation and ten months after removal of the tube. *b*, Stretching of intercartilaginous tissues cephalad to the graft with soft conelike narrowing should be noted.

The third dog had the tube removed five and one-half months after operation, and died two months later. The tantalum mesh was irregular but had not collapsed, and the lumen was decreased to 3 to 4 mm. in diameter by thick granulation tissue which had not been covered by epithelium.

The fourth dog in this group got along better. This tube was removed five months after operation, and the graft seemed rather well healed. Bronchoscopic observation one month later disclosed part of the upper border of the mesh uncovered in the lumen of the trachea. In the next five and a half months, until the animal was killed, the tracheal lumen decreased only slightly while more mesh seemed to protrude into the lumen. At post-mortem exami-

nation the graft area was flattened in an anteroposterior direction and about a third of the upper margin of the mesh was uncovered. About half of the graft area was covered by epithelium (Fig. 4).

COMMENT

The results in our series of repairs with plain fascia are essentially those obtained by others who have described rapid covering of these patches by ciliated tracheal epithelium. Our histologic sections, however, suggest that the autogenous fascia had survived instead of being replaced by new connective tissue and that the epithelium had covered the fascia without need of a granulating base. We were unable to find evidence of regeneration of tracheal mucous glands in the new-formed epithelium. Regeneration of cartilage was observed in a few grafts, a finding reported by others, but it was not sufficient to give adequate tissue support in any instance.

Fig. 4.—Longest survival in Group 5—tantalum with fascia—shows exposure of mesh and only partial epithelial covering of the graft area.

The survival of some of the cartilage grafts was of interest in view of the relatively avascular bed which must surround and nourish such a graft. Our study suggests that thin strips of cartilage might be useful for support of fascial repairs of defects of limited size in man.

The tantalum mesh used in these studies was not responsible for any specific inflammatory reaction on the part of the host tissues. Frequently, the mesh was incorporated in rather thick, firm fibrous tissue, yet microscopic study showed no evidence of any inflammatory reaction to the metal. Rigidity supplied by the mesh was insufficient to prevent deformity caused by contraction of the fibrous tissue. Protrusion of irregular surfaces of mesh or loose wires appeared to be the cause of failure to develop an epithelial lining and of the erosion seen over such areas. However, there was no evidence that the mesh caused damage to adjacent great vessels and esophagus. From these studies it appears that the development of an adequate lining when tantalum mesh is used in repair depends on the following practices: (1) careful folding of mesh edges to eliminate sharp wire ends; (2) careful molding of mesh to the shape of the trachea; (3) use of pieces large enough to lap over the edges of the trachea for at least 1 cm., and (4) placement of the mesh on the outside of the graft.

Temporary use of an inlying polythene tube to support the area of repair was tested because it promised to obviate some difficulties reported in studies in which wire mesh had been used to reconstruct tracheal defects.[2, 17] With such a tube, airtight reconstruction of the airway may be accomplished easily and rapidly. The previously reported finding[4] of epithelium in the area surrounding inlying plastic tubes offered the hope that regeneration of epithelium might occur about a removable tube. It is possible that results might have been improved if we had employed tubes of a different design which fitted better and were left in situ longer. It has been found[13] that polythene tubes of another design prevented stenosis when they were retained for about a year. Under these conditions the fibrous tissue bridging the gap in the trachea became as rigid as the trachea. After removal of the tube, epithelium covered the small, scattered granulating areas, and contraction or significant deformity did not ensue during an observation period of two years.

In the present study we made no attempts to dilate the stenosed part as stenosis was developing.

SUMMARY

Defects of the thoracic portion of the trachea were created in dogs by surgical excision of portions of the wall varying in size from one-half to full circumference and two to eleven tracheal rings in length.

In one group of dogs only autogenous fascia was used to cover small defects. Such grafts survived and were quickly lined by tracheal epithelium. These grafts sometimes contained insignificant amounts of new-formed cartilage but did not possess or acquire sufficient rigidity to warrant their use over large defects.

Autogenous cartilage was placed on the outside of patches of fascia in a group of dogs and was found to survive. Tantalum mesh was used in other dogs after resection of a relatively small segment of trachea to give support to the graft of fascia. The mesh was well tolerated, but tended to be extruded into the tracheal lumen when it was not carefully placed outside of the fascia.

In another group of dogs in which a large portion or long tubular segment of the thoracic part of the trachea was excised, temporary internal support for the area of the repair was provided. Tantalum mesh or fascia covered by tantalum mesh was applied around inlying polythene tubes. The tubes were left in situ for varying periods before removal. Regeneration of epithelium did not take place with sufficient rapidity in the majority of the animals to prevent tracheal stenosis after removal of the tubes. Use of a sheet of autogenous fascia to line the mesh segment failed to improve the end results.

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CONGENITAL ESOPHAGOBRONCHIAL FISTULA IN AN ADULT

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CONGENITAL fistulas between the esophagus and the respiratory tubes were first noted by Gibson in 1696.[1] However, the variations in this anomaly were not adequately described until 1929 when Vogt[2] and later Lanman[3] classified them. The diagnosis and treatment of these defects were evolved largely through the efforts of Haight and Towsley[4] who performed the first successful anastomosis in esophageal atresia with tracheoesophageal fistula, and Ladd[5] who successfully restored esophageal continuity by the construction of an antethoracic esophagus.

Many theories have been advanced to explain the occurrence of these anomalies but their definitive cause is unknown. However, the suggestion that aberrant vessels[6] may play a role in preventing complete separation of the trachea and esophagus seems pertinent in the case we are reporting. Communications between the trachea or bronchi and the esophagus are said to occur about once in every 800 births[6] but they are rarely seen in adult life unless they are acquired. Monserrat[7] reviewed the world literature on this subject in 1941 and found reports of 222 congenital and 448 acquired tracheoesophageal fistulas. However, this figure probably represents but a small portion of their actual number.

Acquired fistulas may be due to neoplasms; infections (lung abscess, suppurative lymph nodes, empyema, tuberculosis, syphilis, and actinomycosis); trauma; foreign bodies (sharp objects swallowed, broncholithiasis[8]); esophageal diverticula with infection; and they may also arise without demonstrable cause. The etiological factors, symptoms and signs, diagnosis and treatment of these lesions have been admirably summarized in recent articles.[9-12]

CONGENITAL RESPIRATORY-ESOPHAGEAL FISTULAS IN ADULTS

We have found reports of congenital tracheo- or bronchoesophageal fistulas in adults in only four proved cases. One of us[13] reported the case of a boy 23 months of age with tracheoesophageal fistula complicated by empyema which may have been congenital in origin. Morton and his associates[14] found an esophageal-bronchial fistula in a 26-year-old man with associated bronchiectasis which was probably congenital. It was resected and a right lower lobectomy was done with good results. Berglund[15] described a 62-

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year-old man who began having symptoms suggestive of tracheal aspiration at the age of 20 years. The patient was not treated surgically and the diagnosis is based mainly upon x-ray studies. Imperatori[16] observed an 8-year-old boy with tracheoesophageal fistula. This child was operated upon shortly after birth for a pyloric obstruction. Later repeated esophageal dilatations were done without relief. Then the fistula was dissected out and tied but it recurred. At a second operation a purse-string suture was placed around the fistula with good results. No biopsies were taken although the fistulous tract was well defined and was probably congenital in origin. Haight[17] reported a well-documented case of a 4-year-old boy with a congenital tracheoesophageal fistula which was diagnosed at birth by Lipiodol studies. The child continued to have a persistent cough and recurrent attacks of pneumonitis. The fistula was successfully divided through a retropleural approach with good results.

Our case is reported for the following reasons: (1) It is rare to find congenital fistulous communications in the adult between the esophagus and the respiratory tubes; (2) it is particularly unusual to encounter such fistulas between the esophagus and the basal bronchus of the left lower lobe at any age; (3) the association of vascular anomalies which may be important in the embryogenesis of such communications as shown by Keith and Spicer[18] and Kraus[19] are illustrated in this patient.

CASE HISTORY

Mrs. R. J. (No. 203306), a Negro woman, 40 years of age, was admitted to the Indianapolis General Hospital on Dec. 6, 1951, complaining of almost continuous productive cough with hemoptysis, chills, fever, loss of weight, anorexia, and extreme weakness. The patient was obviously seriously ill and as we first observed her we noted extreme dyspnea, cyanotic lips, pungently foul breath, frail and emaciated body, and clubbed fingers with advanced osteoarthropathy. We attributed her inability to relate a coherent medical history to the severe illness and also to mental retardation. Therefore, much of our information came from her husband and relatives.

The symptoms had begun in very early childhood; in fact, she could not remember when she had not coughed and brought up sputum. Members of her family informed us that she was a "sickly baby" and that she had a persistent cough at birth and "strangled easily" when she was fed. Throughout her entire life she had been in and out of hospitals. A few of the more significant episodes in her long medical history should be enumerated. The first twenty-five years of her life were marred by constant illness. Although she had been in the hospitals of many cities in the South we were unable to get accurate descriptions from the family or from the patient of the complaints or diagnoses or even the names of any of the hospitals. We do have a record of her admission to a hospital in Nashville, Tenn., in 1937 after a severe attack of pneumonia. She stated that such attacks were very common but that this time the "pneumonia" persisted and the doctors had to remove two ribs; pus drained from the chest for many months. Following her release from the hospital in Nashville, she traveled to many cities and had repeated attacks of what she called pneumonia with a persistent cough, constant tiredness, frequent episodes of hemoptysis, and failure to gain weight. These symptoms led to a diagnosis of tuberculosis.

She was first seen in the Indianapolis General Hospital on Dec. 31, 1941. At this time a diagnosis of multiple abscess of the left lower lobe with severe bronchiectasis was made. The sputum and gastric washings were examined for acid-fast bacilli repeatedly but none were found or cultured. The predominant organisms found were chiefly streptococci, staphylococci, and fusiform bacilli. She was referred to the Chest Service at this

time and a lobectomy was advised. However, after a severe coughing episode an exsanguinating hemorrhage occurred and surgery was deferred. X-ray studies showed a density in the right upper lobe in addition to the disease in the left lower lobe. The erythrocytes at this time numbered two million and the hemoglobin 6 Gm. A progress note on the chart states that the patient's condition was too precarious to permit surgery.

During the next three years the patient came to the Indianapolis General Hospital on the following dates: June 15 to July 15, 1943; Nov. 8, 1943, to Jan. 5, 1944; Oct. 5 to Oct. 13, 1944; May 2 to May 14, 946; June 9 to Aug. 24, 1946; Nov. 10 to Dec. 1, 1946. Her chief complaints on every admission were productive cough (10 to 12 ounces of pus daily) hemoptysis, chills and fever, loss of weight, and weakness. The findings on x-ray examination, bronchoscopy, and bronchography indicated a progressive saccular bronchiectasis with multiple abscess of left lower lobe. Lobectomy was advised each time but refused. Treatment consisted of multiple blood transfusions, postural drainage, antibiotics, and chemotherapy.

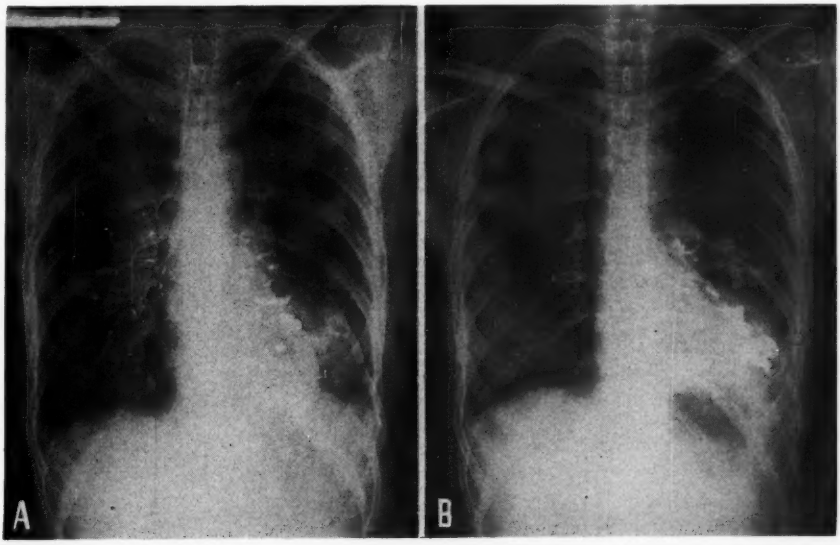

Fig. 1.—*A*, Right bronchogram showing normal bronchial tree. Note the Lipiodol which remains in the left lower lobe from bronchography which had been done six weeks previously. *B*, There is puddling of the Lipiodol in large bronchiectatic cavities two weeks after the left bronchogram had been repeated.

During the next five years the patient entered many hospitals in other cities and then returned to the Indianapolis General Hospital on Dec. 6, 1951, when we saw her for the first time.

One day prior to admission she coughed up approximately 8 to 12 ounces of blood. This frightened the family and she was brought to the hospital prepared to accept the advice of the hospital staff. A complete work-up was started and it was found that many interesting points in her past history had not been recorded on previous admissions. She had never been able to play with other children because of extreme shortness of breath. At times during coughing periods she would cough up small particles of food, milk, and water. After the thoracotomy in 1937 the food particles which she coughed up were much larger and much more frequently observed. Physical examination at this time showed the scar in the lower left chest posteriorly. The entire left lung was dull. There was a to-and-fro murmur heard best over the fourth interspace to the left. Bronchoscopic ex

amination showed a stenosis of the left lower-lobe bronchus, and bronchography revealed multiple abscesses in the left lower lobe and advanced bronchiectasis (see Fig. 1). Some of the Lipiodol which had been injected into the bronchial tree was present in the stomach and for this reason it was decided that a barium swallow should be given. Fluoroscopic observation and x-ray studies showed that some of the barium found its way very easily into the bronchial tree on the left side (see Fig. 2). It was difficult to give the patient

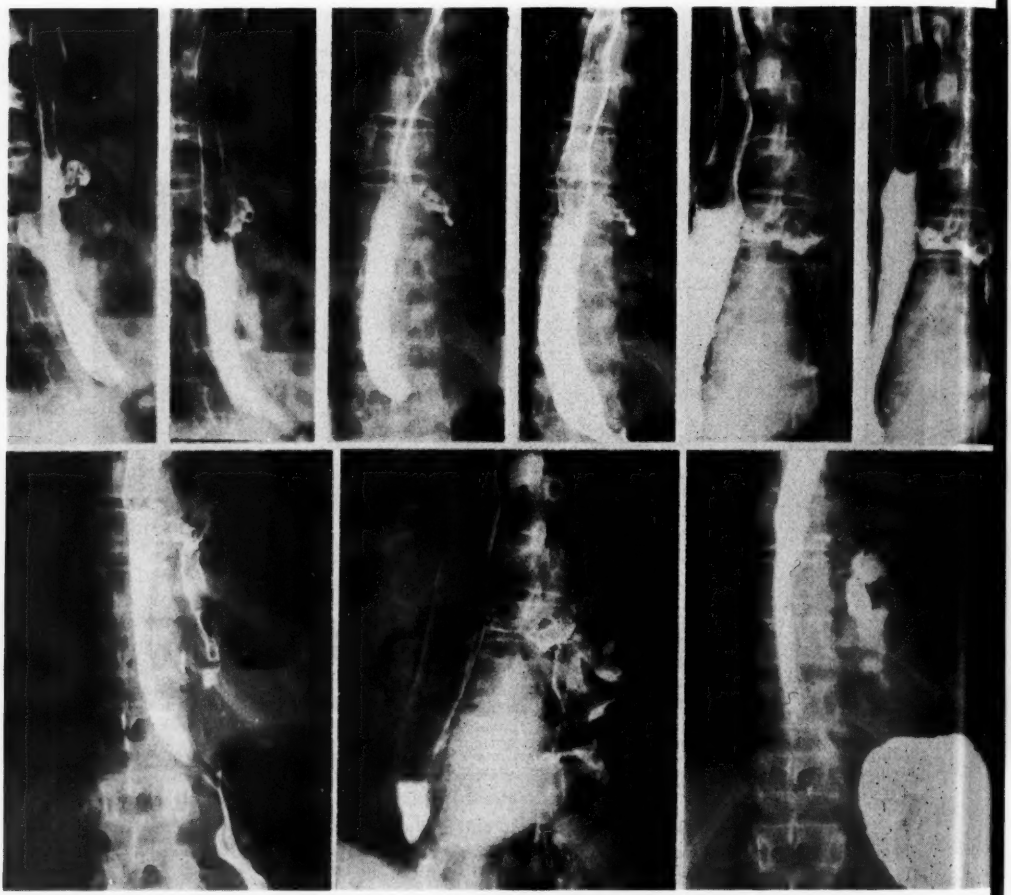

Fig. 2.—Barium swallow. X-ray film taken at one-minute intervals. Note that the left lower bronchial tree is well filled within eight minutes after the ingestion of barium. It is highly probable that the opaque material was propelled by contraction of the smooth muscle in the fistulous tract.

a barium meal because of severe vomiting and therefore the diagnoses of cardiospasm or achalasia were considered. The pulmonary disease could thus be due to aspiration rather than to direct communication. However, after repeated attempts enough barium was retained to demonstrate a bronchoesophageal fistula. The vital capacity was approximately 30 per cent. Erythrocytes numbered 2,900,000, hemoglobin 9 Gm., and leukocytes 14,000. In

spite of the precarious condition of the patient we decided that operation should be done and therefore she was prepared with antibiotics and multiple blood transfusions and exploratory thoracotomy was performed on March 1, 1952.

At operation the visceral and parietal pleurae were found to be densely adherent so that access could not be gained into the pleural cavity without tearing the friable lung and therefore the lung was mobilized by an extrapleural approach. The esophagus was identified and a fistulous tract was encountered which communicated between the esophagus and the basal bronchus of the left lower lobe. The fistula was well defined and was a tubular structure approximately 1½ cm. long and about .6 cm. in diameter (see

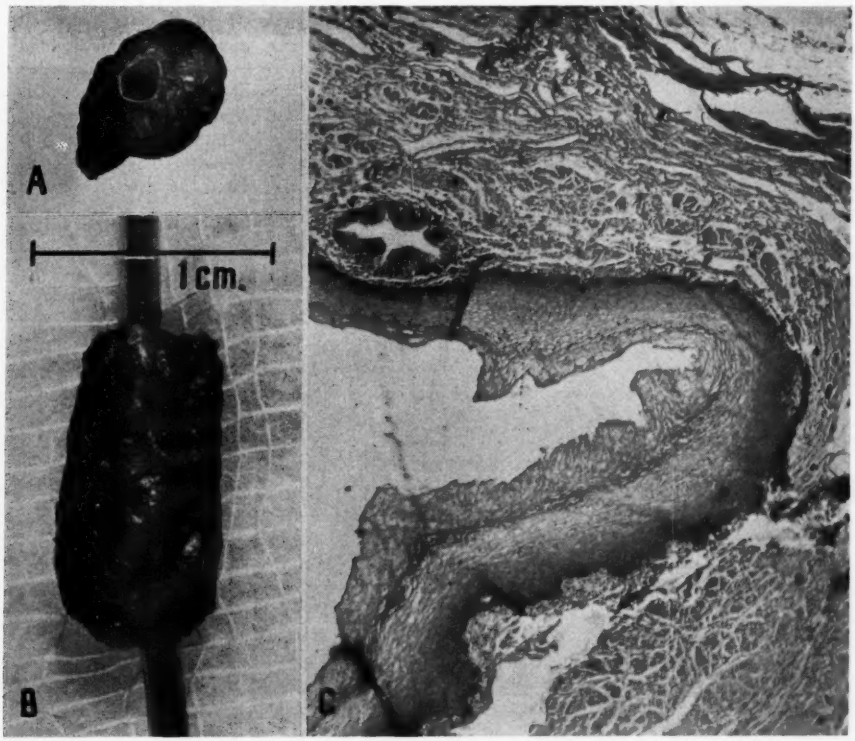

Fig. 3.—*A*, Photograph of the excised esophagobronchial fistula showing the diameter of the opening. *B*, The fistula has been threaded over a small catheter to show its length. *C*, Photomicrograph showing the various layers normally found in the esophagus together with glandular elements. (See text for full description.)

Fig. 3). The fistulous tract was dissected out and removed close to the esophagus. The opening in the esophagus was closed with interrupted 0000 silk. A cuff of fistula was left on the bronchial side which was closed by interrupted 0000 silk sutures. Although a lower lobectomy and lingulectomy was contemplated it could not be done because of a progressive and alarming fall in blood pressure in spite of ample blood replacement. Consequently the chest was closed in layers using 000 silk throughout. The postoperative course was indeed gratifying and surprising. Symptoms abated immediately, there was much less coughing, no recurrence of hemoptysis, and the patient stated that she felt much better.

Microscopic examination* was as follows: Sections through this tubular specimen showed a lining of normal stratified squamous epithelium. The underlying tissue was dense connective tissue which was rather heavily infiltrated with lymphocytes and plasma cells. Outside of this, there was a fairly thick layer of smooth muscle. Within the connective tissue beneath the epithelium several mucus-secreting glandular structures were seen similar to those found normally in the esophagus. No other unusual features were noted in this specimen. Diagnosis was esophagobronchial fistula, congenital.

Eighteen days later the old incision was reopened and the lung freed by extrapleural dissection. This was the only feasible course to pursue since it was impossible to gain entrance into the pleural cavity because of the extremely dense adhesions which existed between the visceral and parietal pleurae. Upon approaching the pulmonary artery it was found that a patent ductus arteriosus was present. This was clamped and divided and closed with a continuous everting mattress suture of 00000 silk supplemented with an over-and-over continuous stitch of the same material. The pulmonary artery side was removed together with the pulmonary artery after ligation proximal to this point. As the individual hilar ligation proceeded it was noted that a second artery was present arising from the aorta immediately above and adjacent to the site of the esophagobronchial fistula and communicating with the basal branch of the pulmonary artery. It was doubly ligated and divided. The lung was removed and the bronchus sutured with interrupted 00 silk sutures. The chest was then closed in routine manner. The patient's postoperative course was entirely uneventful and she was released from the hospital on March 31, 1952, twelve days after pneumonectomy.

The pathology report was as follows:

A. The left lung showed a fairly normal-appearing upper lobe. The lower lobe was roughened and very firm and showed numerous dense adhesions over its pleural surface. The adhesions extended upward along the posterior surface of the upper lobe. Examination of the hilar region showed in one area the presence of a black silk suture about a small piece of fibrous-appearing tissue entering into the pulmonary artery which was stated to be a patent ductus arteriosus. This small strand of tissue was sectioned and labeled "A" in order to identify it. Another section was taken through the pulmonary artery at its point of entry to identify this junction. This structure was not identified grossly with certainty.

B. Another black silk suture in the hilar region was stated to be a point of entry of a congenital fistula. This area was sectioned and labeled "B" for possible identification. No definite structure was identified grossly. This was in the area of the bronchus leading to the lower lobe.

C. Examination of the upper lobe failed to show any gross abnormalities.

D. Multiple sections through the lower lobe showed the entire parenchyma to be honeycombed with multiple abscesses. These varied from .3 to 3.5 cm. in diameter and were all thick walled and surrounded by very dense fibrous tissue. The intervening parenchyma was more firm than normal and appeared to be airless (Fig. 4).

Microscopic.—Section of the abnormal vessel entering the pulmonary artery disclosed smooth muscle and adjacent bronchial elements. In the section taken from the area adjacent to the previously surgically removed esophagobronchial fistula, black silk sutures were seen imbedded in fibrous tissue, the latter being surfaced on one side by stratified squamous epithelium similar to that found lining the fistula (surgical path. No. 527-52-S). Section of the upper lobe disclosed acute congestion of the parenchyma and scanty chronic inflammatory exudate about the walls of small bronchi. The cavities described in the lower lobe, arranged along the continuity of the bronchi, were all lined with respiratory epithelium with the exception of a few areas of squamous metaplasia. These successive dilatations of all the bronchi in the lower lobe represented an advanced

*Described by pathologists, William L. Drake, Jr., and Paul B. Evans.

degree of saccular bronchiectasis. A dense mantle of chronic inflammatory exudate underlay the bronchial mucosa lining these cavities, and there was atrophy of the muscle and cartilage elements in many places. The parenchyma surrounding these cavities was almost completely fibrotic with numerous foci of chronic inflammatory exudate, densely thickened alveolar walls lined by "lining membrane," filled with macrophages. Evidence of specific granuloma was lacking. At several points in the dense, fibrotic parenchyma, there were spherical apertures in the fibrous tissue with "signet ring" arrangement, the nucleus being off to one side, and the picture suggesting a healed lipoid pneumonia.

Diagnosis.—(1) Patent ductus arteriosus of pulmonary artery on the left. (2) Postoperative state, recent, following excision of esophagobronchial fistula, congenital, of lower lobe bronchus of left lung. (3) Chronic inflammation, nonspecific, and fibrosis, of left lung. (4) Bronchiectasis, saccular, advanced, of lower lobe bronchi of left lung.

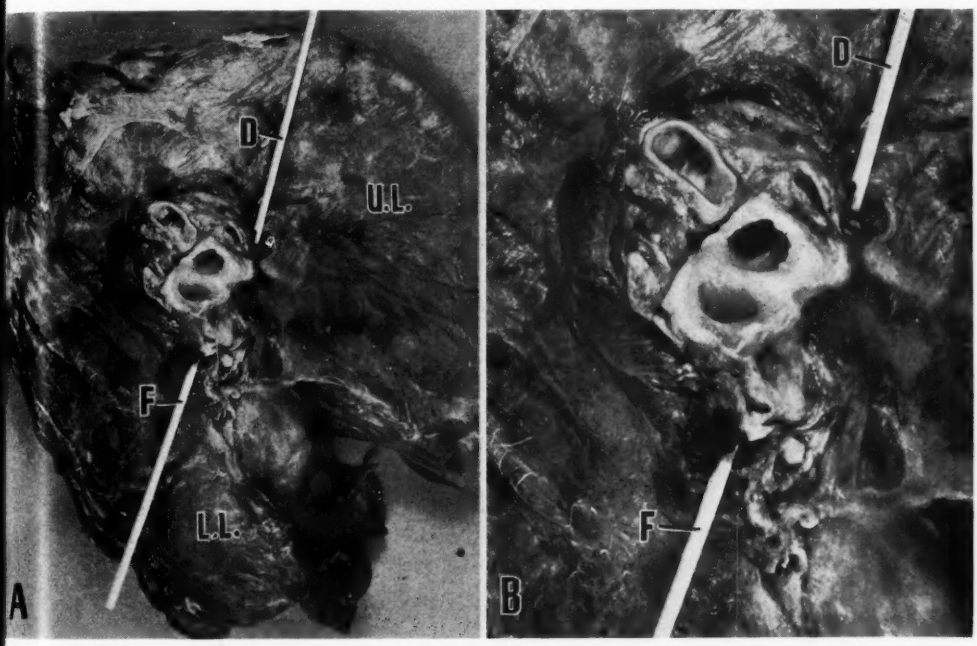

Fig. 4.—*A*, Photograph of excised lung showing the ductus arteriosus (*D*) and the esophagobronchial fistula (*F*). Upper lobe (*U.L.*) appears to be fairly normal but was found to be somewhat involved after microscopic examination. The lower lobe (*L.L.*) is atelectatic and filled with large bronchiectatic cavities. The second ductus is immediately above the esophagobronchial fistula (*F*) but is not clearly shown in the photograph. *B*, Close-up photograph. (See text for full description.)

DISCUSSION

Perhaps many of the so-called spontaneous fistulas which occur in adults are really congenital in origin of the type 3C as described by Vogt or the type 3D as described by one of us.[20] Symptoms may be delayed because of a thin membrane which persists for a time, or as a result of a valvelike fold preventing pulmonary aspiration.

All cases reported in adults gave a long history of persistent cough with repeated attacks of pneumonitis or "pneumonia." This is but another illus-

tration of the necessity for a careful examination in every patient with persistent cough. Esophagography should be included not only because of possible fistulas but also to rule out a pharyngoesophageal diverticulum, achalasia, cardiospasm, and other defects which might lead to regurgitation and aspiration.

Congenital anomalies are likely to be multiple regardless of where the predominant lesion occurs. However, the association of vascular malformations has not been emphasized as a pertinent factor in the embryogenesis of tracheoesophageal communications except by Keith and Spicer and Kraus. Our patient shows the possible causal relationship between such vascular aberrations and the abnormal communication which was present. The anomalous artery or "second ductus" which connected the aorta to the basal branch of the pulmonary artery was adjacent to the fistulous tract and may have interfered with the complete separation of the esophagus from the trachea which normally occurs at about the fifteenth day of fetal life. The patent ductus arteriosus accounted for the to-and-fro murmur which could be heard and also for the retarded mental and physical development of the patient, although chronic pulmonary disease may have similar effects. Perhaps the two "ducti" may have resulted from a double sixth aortic arch on the left; however, we have found no reports of such embryologic deviations.

CONCLUSIONS

1. A case of probable congenital fistula between the esophagus and the basal bronchus in a 40-year-old woman is reported.

2. Associated vascular anomalies were discovered. These consisted of a patent ductus arteriosus at the usual site and an aberrant artery leading from the descending aorta to the basal branch of the left pulmonary artery.

3. There was immediate improvement following ligation and removal of the fistulous tract, and complete recovery following extrapleural left pneumonectomy with ligation and excision of the two ducti.

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CALCIFIC EMBOLI COMPLICATING MITRAL VALVE COMMISSUROTOMY

Report of a Case

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INTRODUCTION

THE increased frequency with which mitral valve commissurotomy is being performed makes it imperative that all its possible complications be recognized so that they may be averted, if possible. Since the operation deals with a valve which is frequently heavily calcified, it was early recognized that the manipulation might dislodge some of this calcific material. Fear of this complication was strengthened by the death of several patients who presented the signs and symptoms of cerebral infarction immediately following surgery. In these patients there were no mural thrombi in the left auricle or atrium. Autopsy failed to recover any calcific emboli in these cases.

We are presenting a case in which the calcific emboli, which originated from the manipulated calcific valve, were recovered at autopsy.

CASE HISTORY

A 26-year-old white man entered Hahnemann Hospital with the chief complaints of shortness of breath and hemoptysis. During the previous three years he had become aware of gradually increasing dyspnea upon routine exertion. At the time of admission he was dyspneic upon ascending a flight of stairs. During the past year he had three episodes of hemoptysis during paroxysms of coughing. The past history was entirely negative, no knowledge of rheumatic affliction having been known until the diagnosis of mitral stenosis was made two months before hospital admission. An allergic history of repeated, rather severe episodes of ivy poison occurring between the ages of 8 and 12 years was obtained.

Physical examination revealed a normally developed, husky, and well-nourished young man with significant findings referable only to the cardiovascular system: there was a diffuse precordial pulsation visible without physical evidence of left ventricular enlargement. Sinus mechanism was present with a blood pressure of 150/70 semirecumbent. In the mitral area, there was a sharp first sound with a grade II, high-pitched, blowing, systolic murmur. Left lateral positioning augmented a long, low-pitched, rumbling diastolic murmur having slight presystolic accentuation. In the third left interspace and along the left sternal border to the apex, there was a grade II, early, high-pitched, decrescendo, diastolic murmur. P_2 was accentuated two plus and there was simple splitting of the second sound in the pulmonic area and along the left sternal border. A Corrigan type pulse was palpated. No signs of congestive failure were found.

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Electrocardiographic tracings indicated right ventricular hypertrophy with atrial dysfunction. Radiologic studies indicated three plus enlargement of the left atrium, two plus enlargement both of the inflow and outflow tracts of the right ventricle, and two plus enlargement of the left ventricle. There was presumptive evidence of calcification of the mitral valve.

Other laboratory studies were within normal limits except for a coagulation time of 18 minutes, 30 seconds. The bleeding time was 2 minutes, 15 seconds. Westergren erythrocyte sedimentation readings were 3 mm. per hour.

Because of a discernible degree of aortic insufficiency, with some left ventricular enlargement, assessment of operability was a most problematic task. In view of the severity of the symptoms attributable to pulmonary hypertension associated with moderately advanced mitral stenosis, and realizing the inability to alter the aortic lesion, operation was felt feasible, justifiable, and rational.[2]

Mitral valvular commissurotomy was performed. The valve was found to be calcified, with some of the calcification having the "cake icing" quality. Technically, the operative procedure was satisfactory.

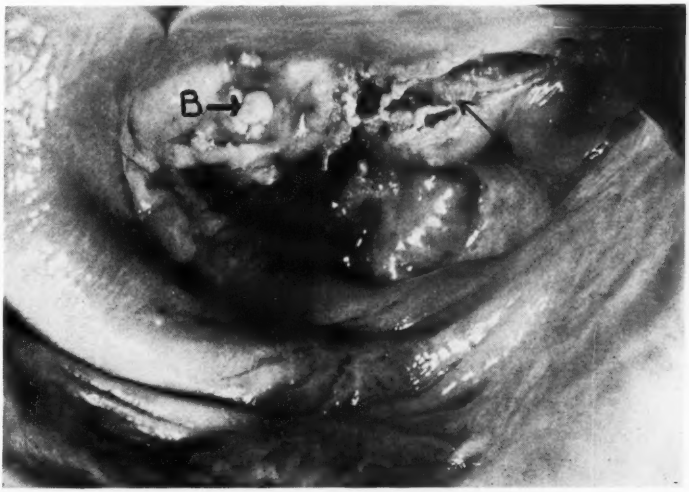

Fig. 1.—Atrial view of mitral valve. Arrow *A* points to granular surfaces of incised lateral commissure. Arrow *B* points to calcified vegetations on atrial surface of mitral valve.

Postoperatively, the patient had right hemiplegia at the time of partial recovery from anesthesia. He responded sufficiently to recognize acquaintances, but no more. A left stellate ganglionic block was performed twice with no appreciable clinical improvement.

Heparinization was accomplished. The patient's blood pressure ranged around 110/50 until twenty hours postoperatively, when it became unstable and even imperceptible on one occasion. At that time he developed paroxysmal muscular twitchings with subsequent tonic rigidity of the lower extremities. Tracheotomy was performed because of accumulating secretions in the tracheobronchial system, and frequent aspirations were necessary.

Three hours prior to death he vomited a moderate amount of dark brown liquid. His abdomen at that time presented no remarkable findings. Blood pressure readings for the last three hours prior to death gradually went from 110/? mm. Hg to 190/? mm. Hg, the temperature suddenly rising from 101° to 104.4° F. (rectally). A pulse rate of 190/min. was recorded. Respirations at no time exceeded 24/min.

Respiratory efforts ceased thirty hours postoperatively.

PATHOLOGICAL OBSERVATIONS

Gross Findings.—General: Autopsy disclosed a left thoracotomy incision which was closed with wire sutures. Also, there was a suprasternal tracheotomy incision.

In the peritoneal cavity there were 200 c.c. of brown nonviscous fluid located in the left subdiaphragmatic space, and 50 c.c. of similar fluid within the pelvis. This liquid had the odor of gastric juice. The capsules of the left lobe of the liver and spleen, and the serosal coat of the splenic flexure of the colon, had finely granular surfaces which were friable. Splenic flexure mesenteric tissues were digested, yielding a dissection of the mesenteric vessels. These were intact and stood out distinctly. The serosa of the descending colon and sigmoid colon was covered with numerous ecchymotic areas. An opening was found along the greater curvature of the fundal portion of the stomach which was 14 cm. long and extended distally from the esophagus. The edges of this opening were irregular in outline and thin. The mucosa of the stomach contained but few rugae, and most of the lining was smooth, thin, and friable, suggesting autolysis.

Fig. 2.—Ventricular view of mitral valve. Arrow points to granular surfaces of the incised lateral commissure.

In the left leaf of the diaphragm there was a hole located in its posterior aspect about 2 cm. to the left of the esophageal hiatus. The edges of this opening were irregular in outline, friable, and thin. Four hundred eighty cubic centimeters of fluid were in the left hemithorax, and in character was similar to that found in the abdomen. Pleural surfaces of the left lung were covered with petechiae.

Pericardium: In the left lateral aspect of the pericardium there was a recent surgical incision whose edges were approximated properly with sutures. The parietal and visceral pericardial surfaces were covered with a fine fibrinous exudate.

Heart: The heart itself weighed 510 grams. On the tricuspid valve leaflets, along the line of closure and on the atrial side, there were firmly attached white verrucae averaging about 3 to 4 mm. in size. The chordae tendineae were thin and delicate. Examination of the mitral valve leaflets showed them to be very thick, rigid and shelflike due to calcification. Fusion along both commissures was evident. On the atrial side there were several firmly attached calcified vegetations about 4 to 5 mm. in size. The valve must have been stenotic and incompetent before operation. The anterolateral commissure had been incised surgically, and the valve opening now admitted two fingers. The edges of the incised portion of the commissure contained friable calcified material which was dislodged easily by running the finger tip over their surfaces. The aortic valve cusps were slightly

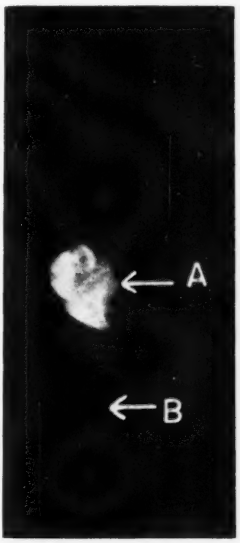

Fig. 3.

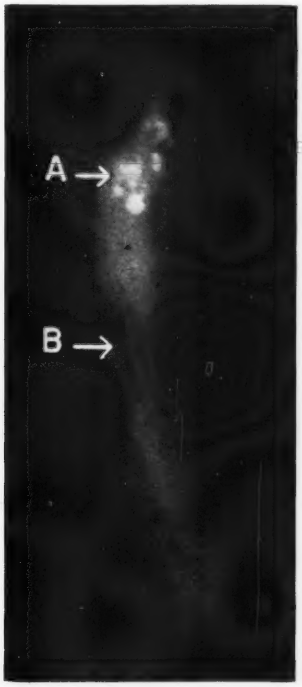

Fig. 4.

Fig. 3.—Roentgenogram of the left middle cerebral artery (*B*), showing radiopaque calcium embolus (*A*) at its first bifurcation. (×9.)

Fig. 4.—Roentgenogram of the left posterior cerebral artery (*B*), showing radiopaque calcium embolus (*A*) in its lumen. (×9.)

thickened but were pliable, approximated one another easily, and held a column of water in the aorta without leakage. No fusion was noted along the commissures, and the valve opening admitted two fingers. There was a purse-string suture on the stump of the left auricle. The myocardium was homogeneous. Hypertrophy of the right ventricle produced a thickness measuring 6 mm. The left ventricle measured 15 mm. The right atrium, right ventricle, and left atrium were dilated. Inspection of the coronaries proved them to be patent.

Brain: Weighing 1,520 grams, the brain showed sulci which were narrowed with flattened convolutions, indicating cerebral edema. The meninges were not remarkable, the sinuses were free of thrombi, and there were no areas of pigmentation.

At the first major bifurcation of the left middle and posterior cerebral arteries the vessels appeared distended. Palpation revealed stony hard masses at these locations, and these were too hard to cut with a knife. Roentgenographic examination indicated these masses were radiopaque and suggested the presence of calcium. Sections of the left cerebral hemisphere revealed two areas of softening, one corresponding to the area supplied by the middle cerebral artery which involved the medial aspect of the temporal lobe and the entire length of the internal capsule and the nuclei on either side. The other area was in the occipital lobe and seemed to involve all of it.

Kidneys: The right kidney contained reddened areas which extended into the cortex.

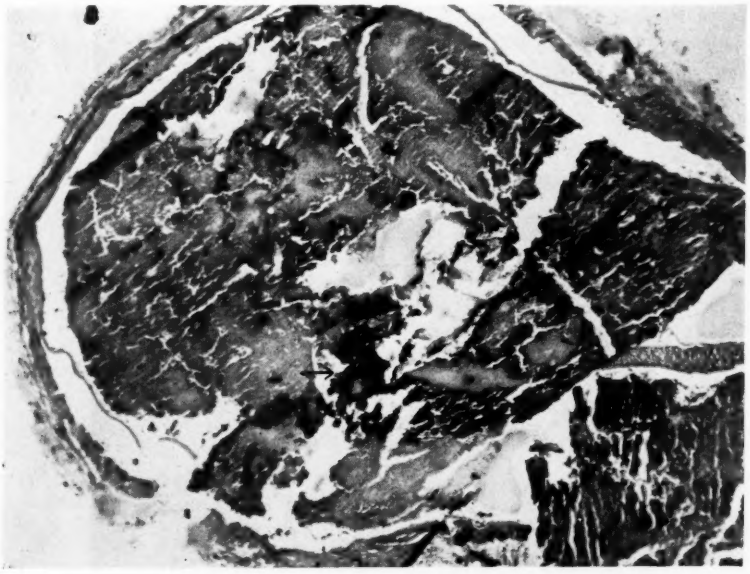

Fig. 5.—Embolus in the lumen of the left middle cerebral artery. Arrow points to calcium particles. Hematoxylin and eosin stain. (×28.)

HISTOPATHOLOGY

Microscopic sections of the tricuspid valve leaflets showed evidence of rheumatic activity. Areas of connective tissue edema and fibrinoid degeneration were apparent. In some fields, there were Aschoff bodies on the valve surfaces. Other fields showed organizing verrucae filled with proliferating fibroblasts. In the sections of the myocardium taken from the base of the left ventricle and septum, there were numerous myocardial and perivascular Aschoff bodies. Several of the smaller coronary arteries showed marked rheumatic arteritis, their lumina being occluded by thrombi. These thrombi did not give a positive reaction for calcium with the Kóssa calcium stain. No areas of myocardial infarction were seen. The pericardium was covered with a thin fibrinous exudate containing a few acute inflammatory cells.

The sections of the left middle cerebral artery showed a normal vessel wall, but the lumen was filled with a thrombus containing numerous homogeneous basophilic particles which stained black with Kóssa's calcium stain, confirming the suspicion that these were particles of calcium. Sections of the left internal capsule and occipital lobe showed areas of infarction with edema, perivascular and intracerebral hemorrhage. Study of sections of the right kidney disclosed two arteries at the hilum which were filled with thrombi

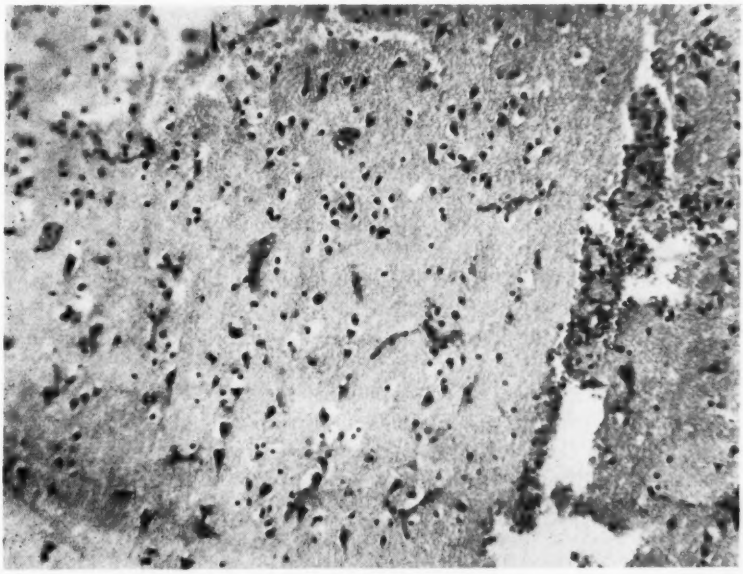

Fig. 6.—Early infarct of the left cerebral hemisphere. Hematoxylin and eosin stain. (×96.

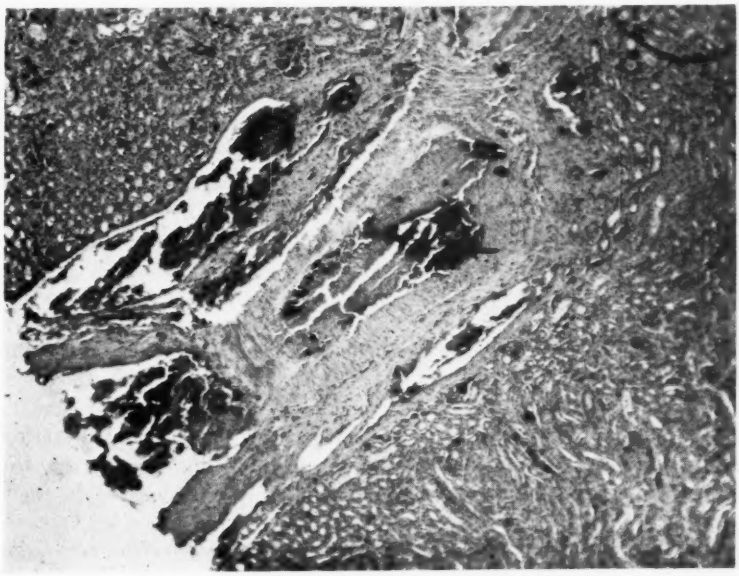

Fig. 7.—Emboli which contain calcium (arrow) in arteries of the right kidney. Hematoxylin and eosin stain. (×96.)

containing homogeneous basophilic particles which stained black with Kóssa's calcium stain. There were areas of fresh infarctions in the medullary and cortical portions adjacent to these arteries.

The tissue taken from the perforated portion of the stomach and diaphragm showed autolysis of the entire thickness of these structures with no inflammatory reaction.

DISCUSSION

The sequence of events in this case seems to have been as follows: With manipulation of the calcified valve, there was dislodgment of several particles of calcium which embolized the left middle and posterior cerebral arteries as well as the right kidney. The emboli to the brain produced infarction of the areas supplied by these occluded vessels, which in turn resulted in the right hemiplegia and hyperpyrexia.

Lack of reaction around the perforated sites of the stomach and diaphragm indicates that these occurred post mortem. The hyperpyrexia this patient had must have facilitated the development of these digestive changes in the four hours elapsing between death and performance of autopsy.

The threat of this complication is definitely greater when the calcified valve is fractured digitally rather than cut, for then there is less control over the operative site, and calcium particles are more likely to be dislodged if in the way of the probing finger.

No previously reported case of calcium embolism complicating mitral valvular surgery could be found in the literature.

In 1950, Moragues, Bawell, and Shrader[1] reported a case of calcific emboli in the coronary artery system. The origin of these emboli was from a nodular calcified aortic valve without bacterial endocarditis. These had become dislodged spontaneously. All other reported instances of emboli to the coronary artery system concerned valves involved by bacterial endocarditis.

With the hope of obviating future difficulties of this type, Dr. Charles P. Bailey now has developed a refinement of the operative technique, which consists of occlusion of the innominate artery and the left common carotid artery at the critical moment when calcium or thrombi may be expected to be dislodged during manipulation of the calcific mitral valve. This procedure is being published in detail elsewhere.[3]

SUMMARY

We have presented a detailed study of a case manifesting a very unusual course of events following mitral valvular commissurotomy for the amelioration of mitral stenosis. A calcific embolus was dislodged from the mitral valve during surgery, resulting in occlusion of the middle and posterior cerebral arteries at their bifurcation. Hemiplegia followed with subsequent death within several hours. Calcium emboli were also located in the right kidney.

Calcium from the mitral valve has been suspected as the source of the cerebral vascular accidents following mitral valvular surgery, but this is the first instance in which the embolus actually has been retrieved from the cerebral vessels.

We wish to express our appreciation to Dr. John E. Gregory, Dr. Charles P. Bailey, and Dr. Lowell L. Lane for their interest, advice, and criticism. We would also like to thank Dr. Harry D. Lykens for taking the roentgenograms of the cerebral arteries.

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RESECTION IN PULMONARY TUBERCULOSIS

Analysis of One Hundred Seven Operations on One Hundred One Patients, with Early Results

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SINCE Freedlander[1] performed the first successful planned lobectomy for pulmonary tuberculosis in 1934, resection in that disease has become increasingly safe. Reference to Table I, which summarizes some of the results collected from the literature, will confirm that impression. Undoubtedly, the adoption of the individual ligation technique in the early forties was a great step forward. Numerous other advances, especially in the fields of anesthesia and blood replacement, have made their contributions. However, it was not until 1947, when streptomycin had gained general usage, that early morbidity and mortality figures showed their greatest improvement. Although it is too soon to evaluate the late results of resection performed under streptomycin, reports such as those by Himmelstein, Berry, and Read[7] are very encouraging.

It is the purpose of this paper to present an analysis of 107 consecutive resections performed on 101 patients at the Connecticut State Tuberculosis Sanatorium, Norwich, Conn., between October, 1948, and July, 1951. Six patients had bilateral resections prior to July, 1951. An additional 3 patients included in this series had contralateral resection without complication subsequent to July, 1951. The latter operations are not included in this analysis. Postresection thoracoplasty was performed in 53 instances without complication. There were 40 men and 61 women. Ages ranged from 15 to 75 years. Ninety per cent of the patients were between 30 and 50 years of age.

A careful study of Fig. 1 will show that our approach to the problem of treating pulmonary tuberculosis by resection was a cautious one. However, it was inevitable that the first patients to have this treatment would be desperate risks. For this reason, a high percentage of the early resections were pneumonectomies. In fact, for the entire series of 101 patients, pneumonectomy was performed in 36, or 35.8 per cent. Another significant observation is that thoracoplasty failure was a major indication for resection in the series. Twenty-eight patients were subjected to some form of resection after having had unsuccessful thoracoplasty. For comparison, a graph has been made of the number of thoracoplasties performed during the thirty-three month interval of this study. This, of course, does not include the number of postresection thoracoplasties. As the number of resections increased, the thoracoplasties diminished rather abruptly during the last few months. There were 34 pure lobectomies but, in addition, there were 11 lobectomies performed in conjunction with seg-

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TABLE I*

AUTHORS	YEARS	PER CENT SPREAD	PER CENT BRONCHO-PLEURAL FISTULA AND/OR EMPYEMA	PER CENT OPERATIVE MORTALITY	PER CENT LATE MORTALITY	PER CENT OF TOTAL NO. OF PATIENTS WITH NEGATIVE SPUTUM AT TIME OF LAST REPORT
Thornton and Adams[2]	Prior to 1942	18.1	37.4	21.7	10.8	
Sweet[3, 4]	1939-1945	7.9	9.5	14.3	30.2	
Overholt et al.[5, 6]	1934-1942	16.7	44.4	27.7	22.2	33.3
	1942-1944	17.6	12.2	14.8	13.5	43.8
	1944-1946	8.7	7.7	10.6	4.8	51.0
	1947-1950	Tuberculous complications	5.7	Total mortality	5.3	
Himmelstein et al.[7]	1939-1946			27.3	13.6	59.1
	1946-1948			9.8	2.0	72.6
Janes[8]	1940-1944	9.4	18.8	9.4	9.4	
Bailey et al.[9]	1941-1946	15.0	27.0	27.0	10.0	55.0
	1946-1948	1.0	7.0	16.0	0.0	77.0
Maier and Klopstock[10]	1942-1944	6.3	12.5	6.3		75.0
Jones and Robinson[11]	1944-1947	20.0	25.7	←——28.6——→		84.4
	1947-1949	4.5	2.3	←—— 5.7——→		(for selected portion of total patients operated upon)
Gale et al.[12, 13]	1945-1948	10.0	2.5	2.5	6.3 (1950)	75.0 (1950)
	1948-1949		7.5	4.2		
Day et al.[14]	1945-1949	13.0	13.0	6.9	5.4	74.3
Chamberlain and Klopstock[15]	1946-1950	2.7	8.0	4.0		86.7
Davidson[16]	1946-1948	3.5	17.5	←——20.0——→		75.5
Johansson and Uggla[17]	1935-1950	13.0 (7 of 54)	11.1 (6)	13.0 (7)	3.7 (2)	66.6 (36 of 54)

*Figures adjusted to make them as comparable as possible from available information.

mental or wedge resections. The remaining 26 patients had either segmental or wedge resections. These are not shown as such on the chart but are grouped with the "combinations."

Indications for resection, at first limited to thoracoplasty failure, bronchostenosis, tuberculous bronchiectasis, tuberculoma, and lower lobe cavity, were gradually extended to include all of those listed in Table II.

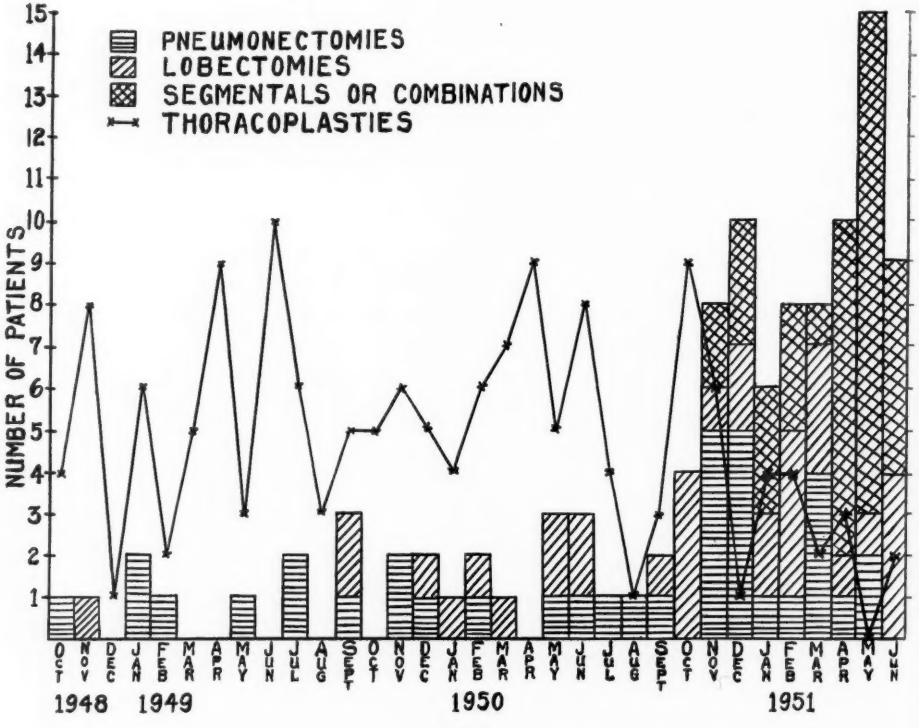


Fig. 1.

Prior to surgery, each patient was carefully evaluated by the combined medical and surgical staffs. Many patients had received prolonged treatment in the form of bed rest, streptomycin, phreniclasis, pneumothorax, pneumoperitoneum, and thoracoplasty. Resection was not performed until lesions in the portion of lung to be conserved were stable, or at least regressive. No patient was refused operation who might benefit from the procedure. In several instances of bilateral, far-advanced disease with cavitation, the cavitary diseased portion alone was removed leaving obviously involved lung behind (Fig. 3, *A*). These patients have done surprisingly well, having been relieved of fever and other symptoms of toxicity. Almost all have negative sputum by smear and culture.

TABLE II

INDICATIONS	NUMBER OF RESECTIONS*
Tuberculoma	9
Bronchiectasis	8
Bronchostenosis	12
Tuberculous bronchitis refractory to treatment	1
Thoracoplasty failure	28
Lower lobe cavity	6
Destroyed lung	8
Destroyed lung with empyema	4
Thick-walled or giant cavity	6
Unexpansible lung requiring decortication	2
To preserve function	28
Suspected carcinoma	3
To avoid deformity in adolescent	1
Patient refused thoracoplasty	2

*More than one indication may have been present for a single resection.

Endotracheal anesthesia supplemented by procaine locally was employed for resection. Intubation was not performed for thoracoplasty. The anesthetic agents most frequently employed were Pentothal Sodium, nitrous oxide, and cyclopropane. Patients were mildly premedicated, and during anesthesia were maintained in as light a plane as possible. Hypoxia and retention of carbon dioxide were prevented by actively assisting respiration. Endotracheal aspiration and inflation of the collapsed lung were frequently carried out. Early in this series, the lateral decubitus position was employed for resections. Three operative spreads of disease occurred in this group of 27 cases. Later, the prone[5] position was employed routinely with no spreads in 80 resections. Postoperatively, the patient was encouraged to cough. Occasionally, endotracheal aspiration and, rarely, bronchoscopy were necessary to remove secretions.

In most instances, the amount of lung tissue to be resected was determined at the time of thoracotomy by palpation. Employment of segmental and wedge resection either alone or in combination with other procedures enabled the surgeon to preserve a maximum of functional tissue. When tuberculous bronchostenosis or bronchiectasis was known to be present, the involved portions of lung were removed, regardless of their appearance at operation. Routine preoperative bronchography was not performed.

Postresection thoracoplasty was performed after each pneumonectomy, and after subtotal resection, if the remaining lung would not fill the hemithorax when the intrapleural pressures had been reduced to minus 10 to 20 cm. of water. All dead space, especially if bronchopleural fistula were present, was

TABLE III. POSTOPERATIVE TUBERCULOUS COMPLICATIONS

	NUMBER OF PATIENTS	PER CENT OF RESECTIONS
Early complications		
Bronchopleural fistula	6	5.6
Bronchopleural fistula and empyema	2	1.9
Postoperative spread	3	2.8
Late complications		
Reactivation	3	2.8
Ulceration of bronchial stump	4	3.7

eliminated as soon as possible (usually in three weeks) by thoracoplasty. It is believed that the low incidence of empyema (Table III) in this series is directly attributable to this principle, which was stressed by Graham[18] in 1933.

Every patient in this series received either streptomycin or dihydrostreptomycin for at least a few days prior to operation and a month following the last operative procedure. After the latter portion of 1949, para-aminosalicylic acid was given with streptomycin. Approximately one-fourth received less than ten days of streptomycin therapy prior to resection. An additional one-fourth had less than 120 days, and all but 4 patients had received less than 240 days of

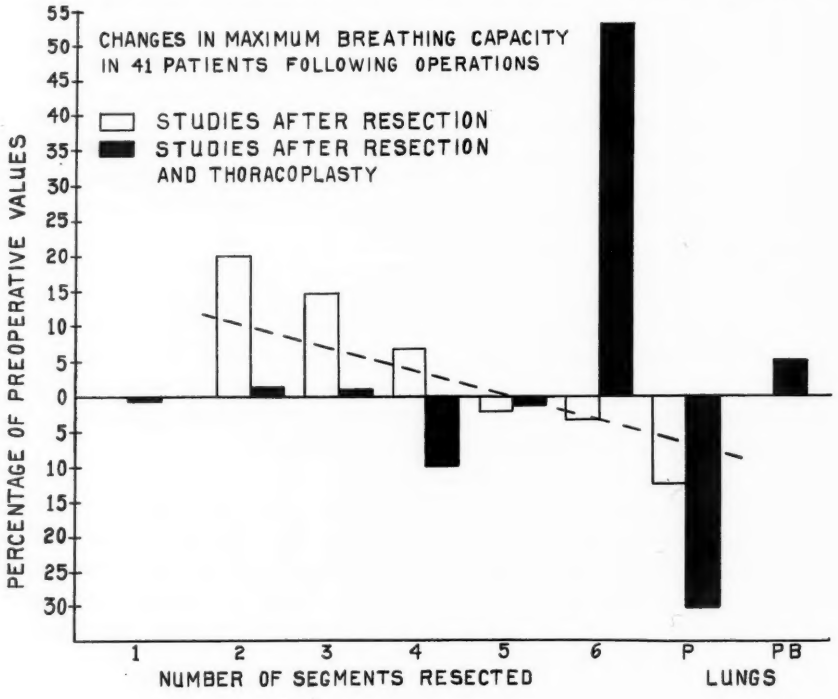


Fig. 2.

therapy prior to operation. Various schedules and dosages were employed according to contemporary practice. Very few patients had long, uninterrupted courses of streptomycin prior to operation. Streptomycin sensitivity studies were not carried out routinely. However, all patients undergoing operation were given the antibiotic. Our impression that this practice is of value appears to be shared by others.[19]

Ventilatory studies were performed preoperatively and postoperatively on 41 patients. The results are summarized in Fig. 2. There was a fairly definite correlation between the number of pulmonary segments removed and postoperative change in maximum breathing capacity, as indicated by the slope of

the broken line. When more than 4 segments were resected, the maximum breathing capacity dropped below the preoperative level. When 2, 3 or 4 segments were resected, there was definite improvement in the maximum breathing capacity in comparison with the preoperative determinations. When partial resection and thoracoplasty were performed, the final maximum breathing capacity was not markedly changed from the preoperative values. There was one notable exception, as seen in the chart, where 6 segments were resected and subsequent thoracoplasty resulted in marked improvement of respiratory function. The diminution of function was greatest in the pneumonectomy-thoracoplasty group, as seen above *P* in the chart. An exception to this rule was noted in the bronchiectatic cases (*P.B.* in the chart), where slight but definite improvement in function was found following pneumonectomy and thoracoplasty.

Tuberculous complications are listed in Table III. Bronchopleural fistula occurred in 8 instances, 1 following pneumonectomy, 2 following lobectomy and 5 following segmental or wedge resection. Thoracoplasty was performed in 6 instances with resultant cure of fistulas. The remaining 2 patients developed empyema and 1 of these died. Spread of disease occurred in 3 instances. These, together with 3 late reactivations, responded favorably to streptomycin therapy. Ulceration of the bronchial stump occurred in 4 instances, all of which had preoperative bronchostenosis. This incidence of 33.3 per cent ulceration in the bronchostenotic group was not serious, however, as the lesions responded readily to streptomycin therapy.

The effect of prolonged (and usually intermittent) preoperative streptomycin therapy on complications is analyzed in Table IV. Although the results of such a small series cannot be taken as statistically significant, there appears to be some evidence that prolonged intermittent preoperative antibiotic therapy had a deleterious effect in every category. This may be an unfair conclusion in the light of the fact that those patients receiving long courses of streptomycin were inclined to have more extensive and more serious disease than those receiving short courses of streptomycin.

The effect of postresection thoracoplasty is similarly analyzed in Table V. Thoracoplasty did not improve the results in any category except bronchopleural fistula, when it was curative in every instance in which it was employed.

TABLE IV. EFFECT OF PREOPERATIVE STREPTOMYCIN ON COMPLICATIONS

	PER CENT OF RESECTIONS RECEIVING MORE THAN 90 DAYS OF STREPTOMYCIN PREOPERATIVELY	PER CENT OF RESECTIONS RECEIVING LESS THAN 90 DAYS OF STREPTOMYCIN PREOPERATIVELY
Early complications		
Bronchopleural fistula	6.1	5.4
Bronchopleural fistula and empyema	2.0	1.8
Postoperative spread	4.1	1.8
Late complications		
Reactivation	4.1	1.8
Ulceration of bronchial stump	4.1	3.6

TABLE V. RELATIONSHIP OF COMPLICATIONS TO RESECTION WITH AND WITHOUT THORACOPLASTY

	PER CENT OF RESECTIONS WITHOUT THORACOPLASTY	PER CENT OF RESECTIONS WITH THORACOPLASTY
Early complications		
Bronchopleural fistula	7.6	0.0
Bronchopleural fistula and empyema	1.3	3.8
Postoperative spread	0.0	11.5
Late complications		
Reactivation	0.0	3.9
Ulceration of bronchial stump	0.0	5.2

Nontuberculous complications are listed in Table VI. There were 13 patients in this group. Although some of the complications were serious, the responses were favorable with appropriate treatment.

TABLE VI. NONTUBERCULOUS COMPLICATIONS

	NUMBER OF CASES	REMARKS
Wound infection	4	This does not include empyema
Atelectasis	3	All responded to aspiration or bronchoscopy
Bronchopneumonia	1	Responded to treatment with antibiotics, apparently not tuberculous
Hemolytic icterus	1	This occurred twice in the same patient, extensive studies failed to reveal the etiology
Postoperative hemorrhage	1	Chest was reopened, severe bleeding apparently emanated from a bronchial artery
Clotted hemothorax	1	Responded to treatment with streptokinase and streptodornase
Toxic psychosis	1	This occurred immediately postoperatively, patient completely recovered
Accidental phrenicotomy	1	

There were 3 deaths in the series, which placed the operative mortality at 2.8 per cent and the case mortality at 3 per cent. The causes of death are listed in Table VII. In the case listed as cardiac arrest, there were some significant observations which deserve comment. The anesthesiologist noted that respirations ceased before the heart stopped beating. This patient was known to have a very flexible chest wall and compressible sternum, apparently produced by a previous thoracoplasty. When she was placed in the prone position and the chest opened, there was a close approximation of the sternum to the vertebral column. Because of the development of respiratory and cardiac difficulties, the patient was turned from the prone to the lateral position. In spite of all the usual and accepted measures directed at resuscitation, the patient died. A

TABLE VII. CAUSES OF DEATH

CAUSE	NUMBER
Cardiac arrest	1
Thrombosis of pulmonary artery	1
Empyema and bronchopleural fistula	1
Total	3

pneumonectomy had been planned, and, therefore, for statistical purposes the case is listed as a pneumonectomy. However, the hilar dissection was scarcely started when it became necessary to abandon the attempt at lung removal. In the next case, the thrombosis of the pulmonary artery was noted at operation. The patient died twenty-four days later of progressive respiratory insufficiency, presumably due to extension of the thrombus into the contralateral lung. The death from empyema and bronchopleural fistula occurred in a patient three and one-half months postoperatively. Even though no attempt has been made to classify the patients relative to their expected ability to withstand operative procedures, it must be admitted that the last 2 patients were desperate risks. Both had long-standing and extensive disease with large cavitations and had received long courses of streptomycin, which probably had produced resistant organisms.

The present status of the 101 patients is summarized in Table VIII. Eighty-two patients now have stable roentgenograms and negative sputum (by concentrated smear and culture). There have been no late deaths. Information on 6 patients is not sufficiently recent to afford accurate classification although, when last heard from, all were well and had stationary roentgenograms and negative sputum.

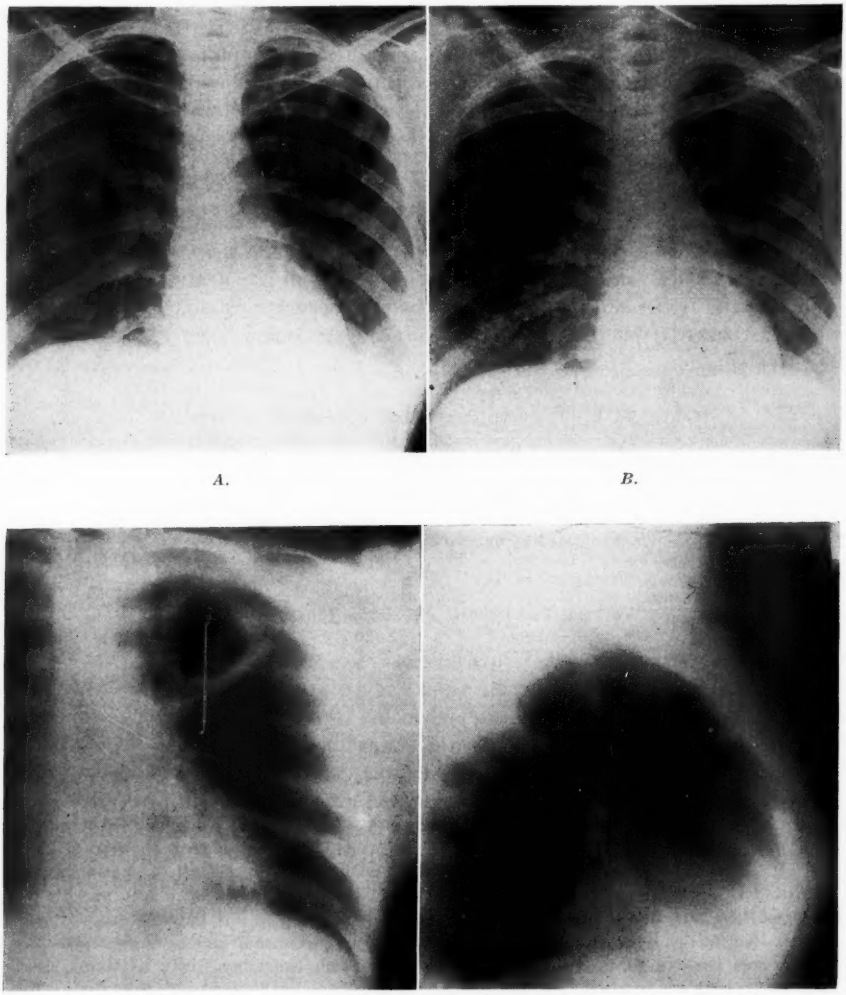
TABLE VIII. PRESENT STATUS OF 98 SURVIVING PATIENTS

	TIME SINCE OPERATION				TOTAL	
	3 TO 4 YEARS	2 TO 3 YEARS	1 TO 2 YEARS	½ TO 1 YEARS	NUMBER	PER CENT
Negative sputum and roentgenograms	–	8	32	42	82	83.7
Positive sputum and/or roentgenograms	–	1	1	8	10	10.2
Inadequate follow-up	1	2	1	2	6	6.1
National Tuberculosis Association Classification						
Inactive	–	7	30	42	79	80.6
Arrested	–	1	2	4	7	7.1
Active	–	1	1	4	6	6.1
Activity undetermined	1	2	1	2	6	6.1

CASE REPORTS

CASE 1.—R. B., a 34-year-old Negro woman was known to have a lesion in her left lung in 1948. She refused hospital treatment at first but later was admitted to a state sanatorium, where she was treated for about five months. Sputum was negative. She left the sanatorium against advice but was readmitted in April, 1949, because of pleuritic pain on the left. Bronchoscopy showed signs of bronchial involvement on the left, and streptomycin (2 Gm. daily) was given for 2 months and then 1 Gm. twice weekly for 5 months. Pulmonary resection, left, was advised, but the patient refused and again left the sanatorium against advice. She finally returned in November, 1950, for the purpose of having a resection. Her sputum was positive for acid-fast bacilli on culture from December, 1950, to March, 1951. She was placed on streptomycin, 1 Gm. and para-aminosalicylic acid, 12 Gm. daily from March 17, 1951, to May 9, 1951. Roentgenograms on readmission showed only slight mottling in the right lung but extensive involvement in the upper portion of the left lung with a cavity at least 3.5 cm. in diameter. Respiratory function test on April 9, 1951, showed a vital capacity of 2.5 L., resting minute ventilation of 7.5 L. and maximum breathing capacity of 57.6 L. per minute. Operation was performed on April 10, 1951. This consisted of segmental resection of the apical and posterior segments of the left upper lobe to include the

large cavity, a wedge resection of a 3 cm. tuberculous abscess of the lower lobe and excision of 2 small pleural abscesses. Postoperatively, the patient had an uneventful course. X-ray pictures were satisfactory, and sputum remained negative. On Sept. 13, 1951, vital capacity was 2.6 L. and maximum breathing capacity was 92.2 L. per minute. She left the hospital against advice on Nov. 16, 1951. Examinations since that time have revealed no evidence of exacerbations of disease.



A. *B.*

C. *D.*

Fig. 3 (Case 1).—*A*, Preoperative roentgenogram of chest showing mottling chiefly on left and large cavity at left apex.

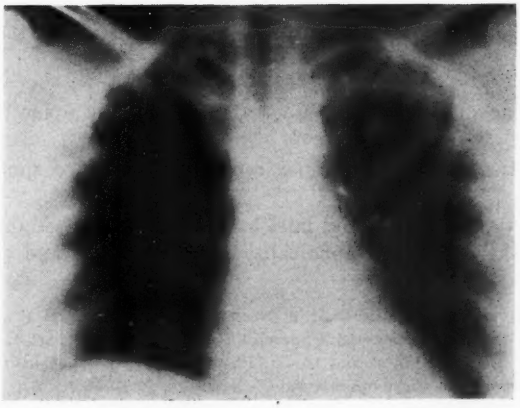
B, Postoperative roentgenogram showing good expansion of remaining portions of left lung and no definite signs of active intrapulmonary disease.

C, Anteroposterior laminagram (preoperative) outlining clearly the large cavity in the upper portion of left lung.

D, Left lateral laminagram showing the apicoposterior location of the intrapulmonary cavity.

CASE 2.—A. P., a 27-year-old white woman had a diagnosis of pulmonary tuberculosis made in 1944. Sputum was positive for acid-fast bacilli, and x-ray examination showed evidence of bilateral pulmonary involvement with cavitation on the right. Right pneumothorax was tried but was not successful. Two temporary phrenic operations on the right were performed on Aug. 31, 1944, and March 1, 1945. On March 5, 1945, pneumoperitoneum was started but immediately discontinued because of unsatisfactory clinical response. Following long-continued bed rest, the patient improved and was discharged in May, 1946. While at home on a modified rest regime, she had a relapse of her disease with positive sputum. She

A. *B.*



C.

Fig. 4 (Case 2).—*A*, Preoperative roentgenogram of chest. Several conglomerate lesions are seen in both apical regions.

B, Postoperative roentgenogram showing relatively clear lung fields bilaterally and good expansion of lungs.

C, Preoperative laminagram showing multiple lesions in both apices and a suggestive region of rarefaction within one dense focus on the left (first anterior intercostal space).

was readmitted to the sanatorium on May 12, 1948. X-ray examination showed increase of disease in the left lung. Streptomycin, 1 Gm. daily, was started on July 27, 1948, and continued for 45 days. Roentgenograms showed improvement, and she was started on graduated exercise. In July, 1949, another relapse occurred with cavity appearing in the right lung, and sputum again became positive. After further rest, the cavity closed, and sputum converted to negative. In April, 1950, she again started exercise, which was followed by another relapse in August, 1950. On Aug. 29, 1950, streptomycin, 1.25 Gm. daily and para-aminosalicylic acid, 10 Gm. daily were started.

Because of repeated relapses of bilateral pulmonary disease, the patient was transferred to surgery. Preoperative roentgenograms (see Fig. 4, *A* and *B*) showed infiltration in both apical regions of the lungs, and the laminagram showed suggestive evidence of a small rarefaction in one of the densities on the left. The first segmental resection was carried out on the left lung on Nov. 10, 1950. This consisted of excision of the apical and posterior segments. Examination of the specimen showed several conglomerate tubercle formations and some liquefaction in the center of one of the larger masses.

The patient's last positive sputum (on culture) occurred on Nov. 6, 1950. Streptomycin and para-aminosalicylic acid, which had been started in August, 1950, were discontinued on Dec. 12, 1950. Because of the presence of lesions in the right lung, the patient was allowed a period of rest and then started on a final course of streptomycin and para-aminosalicylic acid on Feb. 9, 1951. This was continued until March 13, 1951. On Feb. 13, 1951, an operation consisting of excision of the apical and posterior segments of the right upper lobe was performed. Upon examination, several small caseous foci were found, but no cavity was present. Postoperatively, the patient's convalescence was favorable, and she has remained well.

CONCLUSIONS

A review of the recent literature, as well as our own experiences, reveals that treatment of tuberculosis by resection is not only a safe, but a highly effective, procedure. The early results compare favorably with those of thoracoplasty. Postoperative decrease in ventilatory function is less than that following thoracoplasty since collapse is necessarily greater when the latter procedure is employed as a therapeutic measure. Although a number of years must elapse before this series can be completely evaluated, we have not noted a high incidence of late complications in the earlier cases.

SUMMARY

1. Experiences with 107 resections for tuberculosis upon 101 patients are reviewed.

2. Eighty-two patients (83.7 per cent) have negative sputum and roentgenograms.

3. Morbidity, both early and late, has been relatively slight.

4. There was an operative mortality of 2.7 per cent and a case mortality of 3 per cent.

The authors wish to express their appreciation to the Medical Staffs of Cedarcrest, Laurel Heights, Uncas-on-Thames and Undercliff Sanatoria for the part they have played in the treatment of these patients, and to Dr. Phyllis C. Frost, who skillfully administered anesthesia in almost all of these operations.

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LOCALIZED PULMONARY HYPERTROPHIC EMPHYSEMA

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LOCALIZED pulmonary hypertrophic emphysema is an extraordinarily rare type of cystic disease of the lung. In several recent articles, clinical, radiologic, and pathologic data have been published which indicate that the disease is a definite entity and that it is congenital in origin. The radiologic features follow a rather easily recognized pattern, and permit the diagnosis to be made with considerable accuracy. In the five articles on this subject previously published, ten examples of the disease have been described. The two adult patients in this group are not entirely acceptable for consideration; in one of these[1] the disease was an incidental autopsy finding, and in the second patient[2] there was associated sarcoidosis of the lung and hilar glands. All of the eight remaining cases[3-5] occurred in infancy or early childhood. These data indicate that the disease is not compatible with long survival, and that operative treatment should be instituted promptly when the diagnosis is made. In the following report another infant having this disease will be described. The patient was subjected to lobectomy; two episodes of cardiac arrest occurred during the procedure, but the patient made a good recovery.

REPORT OF CASE

This infant presented symptoms of asthma, and this disease was present in other members of his family. When first seen the patient had a superimposed acute laryngotracheobronchitis, and this served further to confuse the diagnosis. The chest roentgenogram suggested obstructive emphysema, and a bronchoscopic examination was made in search of a foreign body. Marked emphysema limited to the middle lobe of the right lung was found at operation.

A poorly developed, malnourished, 7-month-old male infant, who was dyspneic from birth, was admitted to the hospital* on Dec. 26, 1948, because of cough, dyspnea, and cyanosis. The history recorded that wheezing and dyspnea had been present since birth, and that a diagnosis of bronchial asthma had been made. Symptomatic relief had been obtained with Adrenalin on several occasions. The infant's temperature on admission was 102° F.; the chest was barrel-shaped; respiration was rapid, with audible inspiratory and expiratory wheezing. There was moderate inspiratory retraction at the costal arch and jugular notch. The admission diagnosis was acute tracheobronchitis and bronchial asthma. A chest roentgenogram demonstrated hyperaeration on the right with partial atelectasis of the lower lobe. The heart and mediastinum were displaced to the left (Fig. 1). The lateral view demonstrated increased anteroposterior diameter of the chest (Fig. 2).

The signs of tracheobronchitis subsided promptly, but the wheezing, dyspnea, and roentgen findings remained unchanged. At this time it was believed that we were dealing with some unusual manifestation of tracheobronchitis, and that extrinsic pressure from

From the Surgical Department, Binghamton City Hospital.
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*Service of Dr. E. R. Dickson.

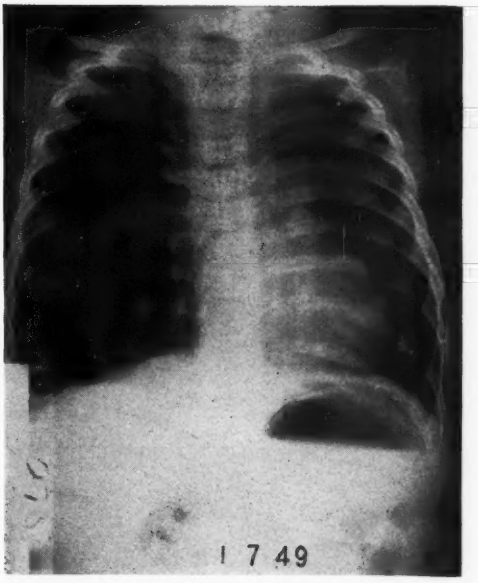

Fig. 1.—This anteroposterior roentgenogram demonstrates hyperaeration and decreased lung markings on the right with mediastinal displacement to the left. The partially atelectatic right lower lobe is clearly seen. The right hemidiaphragm is depressed, and the interspaces are widened.

Fig. 2.—In this lateral roentgenogram the emphysematous-shaped chest is demonstrated; hyperaerated lung is seen anteriorly.

enlarged bronchopulmonary glands, or, possibly, a foreign body was producing obstructive emphysema. A bronchoscopic examination was made; diffuse inflammation of the tracheobronchial tree was seen, and no foreign body was found. Following this procedure an acute exacerbation of the patient's symptoms occurred within forty-eight hours. The infant's respiratory distress became extraordinarily severe; his temperature fluctuated between 100° F. and 105° F., and for a time it appeared certain that he would not recover. At the end of one week aureomycin was administered; remarkable improvement followed almost immediately, and the infant's temperature was normal within twenty-four hours. Two weeks later the patient was discharged; at this time the roentgen findings were unchanged, and he continued to present symptoms and signs of asthma.

Following his release from the hospital the infant's condition remained stationary. He was readmitted five months later for a period of one week, at which time he had an acute upper respiratory infection with exacerbation of his symptoms. A tuberculin test was negative, and he gave a one plus reaction to several allergens. The chest roentgenogram

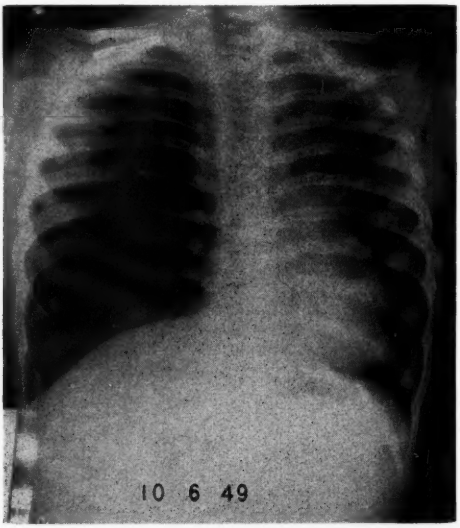

Fig. 3.—This preoperative roentgenogram was exposed ten months after the study illustrated in Fig. 1. The emphysema is more extensive and increased collapse of the lower lobe of the right lung has occurred. The mediastinum is now widely displaced to the left.

was identical in appearance to that seen during his original admission. At this time a diagnosis of cystic disease of the lung was made. An operation was done on Oct. 11, 1949, under intratracheal ether-oxygen anesthesia; the patient was then 17 months old. The preoperative chest roentgenogram is shown in Fig. 3.

Operation.—At operation the enormously enlarged emphysematous right middle lobe bulged out of the wound as the pleura was opened. The upper and lower lobes were almost completely atelectatic. The vessels and bronchus of the middle lobe were elongated, and lobectomy was easily done by individual ligation technique. The patient's condition was excellent up to the time that the lobectomy was completed. Cardiac arrest then occurred; ventilation of the lungs and cardiac massage was immediately done, and vigorous action returned after about one minute. Drains were placed and closure was started when cardiac arrest again occurred. Resuscitation for about one minute was again followed by recovery; the operation was then completed without incident.

*Gross Pathology**.—The specimen measured 11 by 8 cm. The surface was pale white, and was studded with numerous subpleural blebs which measured 4 to 10 mm. in diameter. It was feathery in consistency; on section it was spongelike; there was no gross abnormality of the larger bronchi (Fig. 4).

Microscopic Findings.—The peripheral portion of the lung consisted of large ballooned-out spaces produced by intercommunicating alveolar sacs. In places the alveolar ducts up to and including the respiratory bronchioles formed part of the wall of these spaces. These bleblike structures were apparently formed by destruction or absence of interalveolar septa.

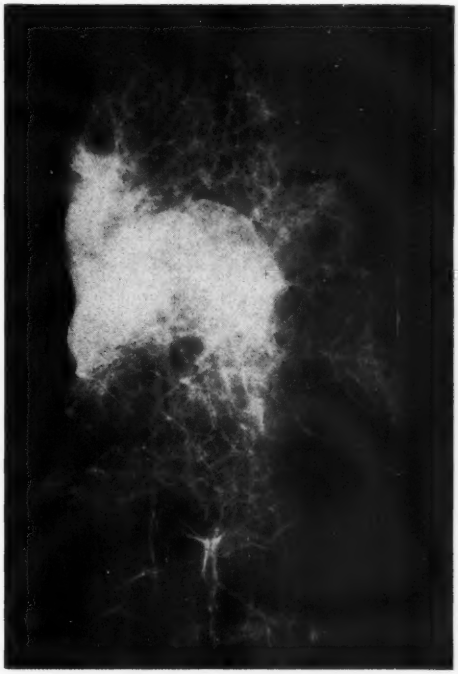

Fig. 4.—This roentgenogram of the operative specimen was exposed about one hour after its removal. Very little collapse occurred, although the bronchus was not clamped and the specimen was not inflated. The density in the hilar area is a hematoma produced by operative trauma. This study actually demonstrates the pathology better than the dissection of the gross specimen.

Some of these septa revealed marked bulbous thickenings; in others the interalveolar septa were extremely delicate structures lined with flattened cells. Some of the alveolar spaces were filled with precipitated albuminous edema fluid; a few small foci of low-grade inflammatory reaction were present. This picture suggests a type of congenital cystic disease of the lung in which the terminal and respiratory bronchioles do not constitute the major part of the picture.

Postoperative Course.—The patient reacted promptly following the operation, and convalescence was rapid and without incident. The upper and lower lobes expanded perfectly; the wound healed by primary union, and the patient was discharged from the hospital on the sixteenth postoperative day.

*Pathology report by Dr. J. S. Grewal, Director, Kilmer Memorial Laboratory.

Subsequent Course.—Following his discharge from the hospital the patient's barrel-chest deformity was rapidly corrected, and he has remained well. He has been followed for over two years and now appears to be normal in every way. A chest roentgenogram exposed fourteen months after operation is reproduced in Fig. 6.

REVIEW OF LITERATURE

Clinical and Radiologic Data.—Data referable to the above patient and the other previously published examples of this disease have been assembled in

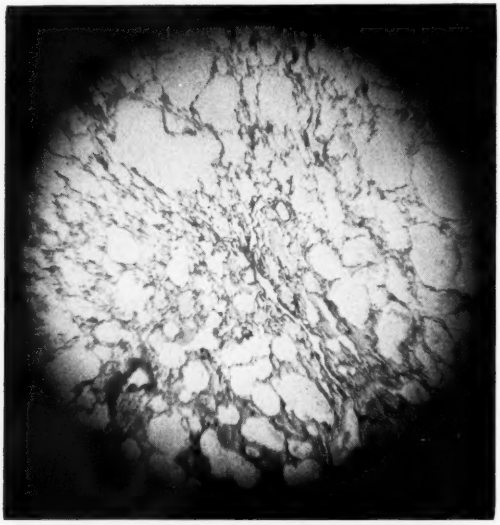

Fig. 5.—This photomicrograph demonstrates the extensive pulmonary emphysema.

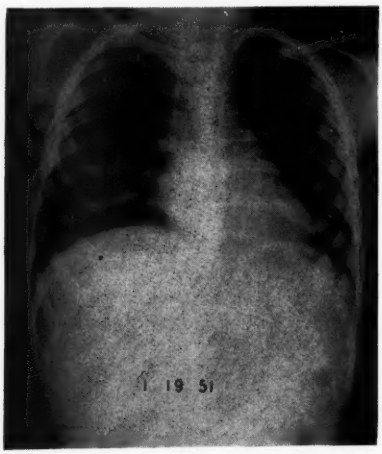

Fig. 6.—This negative postoperative chest teleoroentgenogram was exposed ten weeks after operation.

TABLE I

AUTHOR	DATE	AGE	SEX	EXTENT OF DISEASE	SYMPTOMS	X-RAY FINDINGS	TREATMENT	RESULT
Royes	1938	38 yr.	M	Segment of right middle lobe	Unknown	No examination	None	Incidental autopsy findings
Sweet	1950	34 yr.	M	Mainly left upper lobe	Dyspnea on exertion	Typical	Left pneumonectomy	Recovery. Sarcoid disease was present in the resected lung and hilar glands.
Leahy and Butsch	1949	14 wk.	M	Left upper lobe	Wheezing, dyspnea, sternal retraction	Typical	Lobectomy	Recovery
Robertson and James (5 cases)	1951							
	Case 1	14 wk.	M	Right upper lobe	Dyspnea, cyanosis, sternal retraction	No examination	Oxygen therapy	Died (autopsy)
	Case 2	2 wk.	M	Right upper lobe	Dyspnea, cyanosis	Typical	Lobectomy	Recovery
	Case 3	9 mo.	M	Right upper lobe	Wheezing, dyspnea, cyanosis	Typical	Needle deflation	Died (autopsy)
	Case 4	8 wk.	M	Left upper lobe	Cyanosis	Typical	Lobectomy	Recovery
	Case 5	11 mo.	F	Right middle lobe	Cyanosis, wheezing	Typical	Aspiration-subaqueous deflation lobectomy	Recovery
Shaw (2 cases)	1951							
	Case 1	4 yr.	M	Subapical segment left upper lobe	Wheezing	Typical Associated funnel-chest deformity	Segmental resection	Recovery
	Case 2	7 wk.	F	Right middle lobe	Wheezing, dyspnea, sternal retraction	Typical	Lobectomy	Recovery
Present Case	1952	17 mo.	M	Right middle lobe	Wheezing, dyspnea, sternal retraction, attacks of cyanosis	Typical Associated barrel-chest deformity	Lobectomy	Recovery

Table I. Although they have been included in other reports, neither of the two adult patients appears to be entirely acceptable for study. Excluding these two patients, nine examples, all occurring in infancy or early childhood, remain for analysis. Seven patients were males and two were females; wheezing, dyspnea, cyanosis, and sternal retraction were the outstanding symptoms. The disease was limited to a single pulmonary segment in one instance; in the remaining eight the process was confined to a single lobe. The upper lobes and the right middle lobe were involved with equal frequency; there was no example of the disease occurring in either lower lobe. Chest roentgenograms of eight patients were made. In every instance these studies demonstrated hyperaeration of the affected lung with decreased lung markings, mediastinal displacement toward the contralateral lung, and various degrees of depression of the diaphragm and widening of the interspaces of the involved hemithorax. The roentgenogram of Shaw's Case 2 was identical to that of the patient reported here. In both patients the disease involved the middle lobe of the right lung, and in both the partially atelectatic lower lobe on the same side was clearly demonstrated.

Treatment.—Lobectomy or segmental resection without mortality was accomplished in seven patients. One patient, whose chest was deflated with a needle, developed a tension pneumothorax and subcutaneous emphysema followed by a fatality. Thoracentesis was done in another instance with the occurrence of tension pneumothorax. This complication was successfully managed by continuous subaqueous deflation. This patient was subsequently subjected to lobectomy and recovered. This experience should condemn aspiration as an ineffectual and dangerous procedure in this disease.

Pathology.—Surgical specimens or autopsy material has been available in all of the patients under consideration. The gross appearance of the involved lung was remarkably uniform. Its surface was white or pale pink, with numerous subpleural emphysematous blebs; on palpation it was feathery, and on cross section spongelike in consistency. At operation the diseased area usually filled the entire hemithorax, and frequently bulged out of the wound when the pleura was opened. Uninvolved lobes on the affected side were partially or completely atelectatic. The vessels of the involved lobe or segment were smaller and longer than average. Following resection excellent expansion of the compressed lobes occurred.

Inflammation was notably absent in the microscopic studies. The atria and alveoli were distended; septa were frequently ruptured, and the alveolar walls were usually thin. Collapsed bronchi with areas of atelectasis alternating with distended air sacs were present in one specimen.[3]

Etiology.—The onset of symptoms at, or shortly after birth, and the roentgenographic evidence of extensive disease in the first weeks of life, together with the absence of inflammation in the surgical and autopsy material, all strongly indicate that this disease is congenital in origin. Anatomic anomalies which might place this disease in the category of an acquired or developmental defect have been proposed. A valve mechanism produced by a fold of mucous membrane in the stem bronchus of the involved lobe was believed by Royes[1] to be the etiological factor in his case. Robertson and James[4] also found such a

fold in one of their patients. In another instance the latter authors believed that a thin-walled bronchus might have been compressed by a large adjacent vein. Shaw[5] found unusually flaccid bronchi in his operative specimens, and has suggested that a localized bronchial chondromalacia might be the underlying pathology. An excellent discussion and review of the literature relevant to this aspect of the disease are included in the article of Leahy and Butsch.[3]

SUMMARY

Lobectomy in an infant having massive hypertrophic emphysema of the middle lobe of the right lung is reported. Two episodes of cardiac arrest occurred during the operation, but the patient made a good recovery. The literature relevant to this disease is reviewed, and the clinical, radiologic, and pathologic data are summarized. All of the nine well-documented examples of the disease thus far published have occurred in infancy or early childhood. Among these, seven were subjected to lobectomy or segmental resection without mortality. The available information indicates that the disease is a clinical entity of congenital origin, and that resection should be done promptly when the diagnosis is made.

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ACUTE TUBERCULOUS FIBRINOUS BRONCHITIS

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FIBRINOUS bronchitis comprises a generic group of bronchial inflammatory diseases which has as its characteristic clinical feature the formation of bronchial casts. The expectoration of casts of the bronchial tree is such a singular clinical phenomenon that the disease has been recognized since the time of Galen. In spite of its long history, only about 200 cases have thus far been reported.[6] In the majority of these patients the bronchial inflammation has been produced by one of the common pyogenic bacteria; examples of the disease due to *Myobacterium tuberculosis* are exceptional. In the following report a patient having fibrinous bronchitis of tuberculous etiology will be described. This patient presented the clinical picture of severe anoxia due to bronchial obstruction. At bronchoscopy inspissated tenacious bronchial casts were found, the removal of which required a foreign body forceps. Tracheotomy was necessary and the patient subsequently developed a bronchial stricture and bronchiectasis which required pneumonectomy.

REPORT OF CASE

A 38-year-old woman, who had had tuberculous cervical adenitis twelve years previously, developed wheezing and a dry cough following an upper respiratory infection. A diagnosis of bronchial asthma was made; chloramphenicol and antihistamine therapy were administered without benefit. Paroxysms of coughing with dyspnea and cyanosis developed within a few weeks, with progression in their frequency and severity. Ten weeks later the patient was hospitalized after a particularly severe exacerbation of these symptoms.

On admission to the hospital on March 11, 1951, the patient's temperature was 101° F, the pulse rate was 120, the respirations were 40, she was pale, and her fingernails were definitely cyanotic. In addition, she was weak, hoarse, and had a dry, brassy nonproductive cough. Physical examination demonstrated no significant findings other than distant breath sounds over the entire left lung. The white blood cell count was 21,000, with 78 per cent neutrophils; the red blood cell count was 4,830,000; the hemoglobin was 78 per cent; the urine contained a trace of albumin. A chest roentgenogram was negative (Fig. 1). The admission diagnosis was bronchial adenoma.

Two days following her admission, the patient had a severe coughing paroxysm followed by alarming dyspnea and cyanosis which was not relieved by oxygen. Bronchoscopy was done as an emergency measure. Catarrhal inflammation of the larynx and trachea was present, and the left main bronchus was found to be almost occluded by tenacious, firm, grayish-white, inspissated material. This could not be aspirated, and it was laboriously removed in small fragments using a foreign-body forceps. After the removal of the cast, the bronchial mucous membrane was seen to be intensely inflamed; it bled on contact with the aspirator. At the end of the procedure the patient's anoxia was relieved; she then sat up on the operating table, coughed effectually, and raised several additional pea-sized frag-

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From the Surgical Departments of Our Lady of Lourdes Hospital, Binghamton, N. Y., and Charles S. Wilson Memorial Hospital, Johnson City, N. Y.

ments of identical material. During the next twenty-four hours a recurrence of the alarming respiratory distress required a second bronchoscopy with removal of inspissated secretions; this procedure was followed immediately by a tracheotomy.*

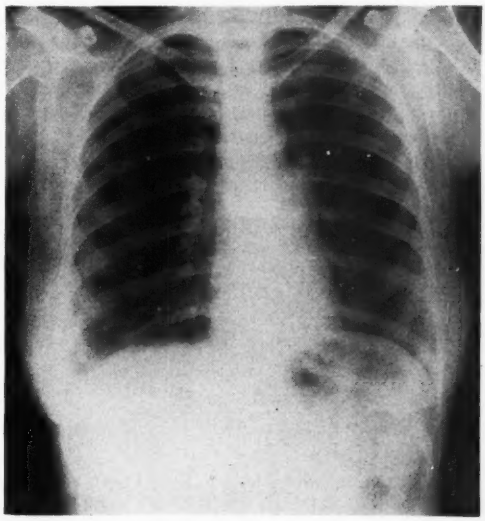

Fig. 1.—This chest roentgenogram was exposed a few hours before the first bronchoscopic procedure. Both lungs are well aerated, although signs of obstruction of the left main bronchus were present. This study was believed to be negative, but in retrospect the prominent left hilum shadow suggests the presence of disease in the superior segment of the lower lobe.

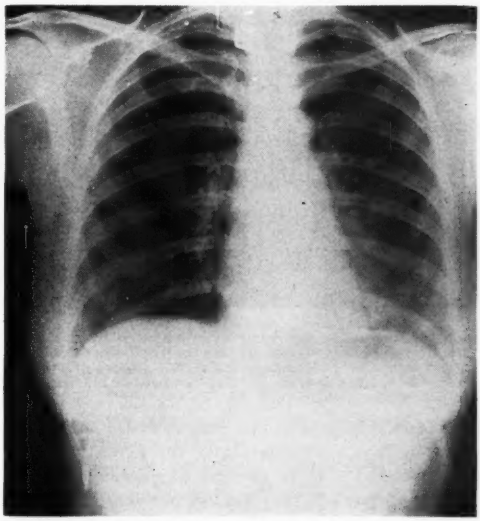

Fig. 2.—This roentgenogram was exposed nine days following the second bronchoscopic procedure and tracheotomy. A bronchopneumonic infiltration is seen on the left; lateral studies localized this process in the lower lobe.

*By Dr. Manuel M. Monserrate.

Postoperatively, frequent tracheal aspirations with a prostatic-type catheter were effectual in clearing the tracheobronchial tree. The septic fever continued, and the chest roentgenogram demonstrated a scattered infiltration in the lower lobe of the left lung (Fig. 2).

A specimen of the material collected at bronchoscopy for culture was erroneously submitted for biopsy. It contained gram-positive cocci and gram-negative bacilli; no acid-fast organisms were found. Secretion aspirated after tracheotomy yielded a growth of several pyogenic organisms. Antibiotic therapy with penicillin was started; no response was obtained, and this agent was followed by terramycin. The patient improved following administration of the latter antibiotic, but she did not become afebrile until three weeks after the operation. At this time the tracheotomy tube was removed and the patient was discharged from the hospital, although the infiltration in the left lung was not entirely resolved.

Fig. 3.—This photograph of the left lung demonstrates the inflammation of the bronchi and the extensive suppurative and caseous disease in the lower lobe. The bronchial disease has not progressed to the stage of stenosis, and the narrowing of the main bronchus is much less prominent than would be expected from its appearance at bronchoscopy.

Following release from the hospital the patient failed to make satisfactory progress. The tracheotomy sinus did not heal; the septic fever recurred; she again developed a severe brassy cough and raised a large amount of purulent sputum. The inflammatory process in the lower lobe of the left lung did not resolve, and a new area of infiltration appeared in the upper lobe. Sputum cultures were made, and eight weeks later one of these was reported positive for tuberculosis. Numerous additional cultures were negative before this finding was confirmed. A bronchoscopic examination at this time demonstrated

acute inflammation and marked narrowing of the left bronchus. It was then obvious that severe bronchiectasis was also present, and the patient was accordingly prepared for pneumonectomy. A good remission of symptoms followed six weeks' therapy with PAS and streptomycin. Pneumonectomy was done on Oct. 30, 1951, under intratracheal ether-oxygen anesthesia using the prone position. A bronchoscopic aspiration was done at the end of the procedure.

Forty-eight hours after operation the patient began to develop slight hoarseness and difficulty in raising bronchial secretions, which were unusually viscid. Progression of these symptoms occurred during the next twenty-four hours, and the patient required oxygen. A tracheotomy was then done; a large amount of ropy, viscid, purulent secretion was evacuated, with striking relief.* Convalescence thereafter was uninterrupted. The tracheotomy tube was removed after one week, and the patient was discharged ten days later.

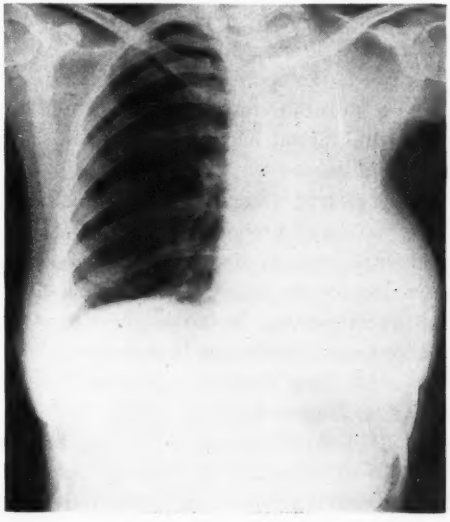

Fig. 4.—This roentgenogram was exposed seven weeks after pneumonectomy. A modified thoracoplasty has been done; the right lung is clear.

Gross Pathology.†—The main bronchus, its major branches, and even the smaller ramifications were filled with gray, tenacious, purulent material. Both lobes were only partly aerated. The upper lobe in its lower four-fifths was airless and rubbery. The medial portion of the lower lobe was atelectatic and nodular. Multiple discrete grayish, small, white, firm foci, which measured up to 6 mm. were present in both lobes; these foci were less numerous in the upper lobe (Fig. 3).

Microscopic Findings.—The main bronchus showed absence of epithelium with formation of acutely inflamed granulation tissue. Bronchi of all sizes were characterized by a dense lymphocytic infiltration with partial or complete destruction of muscularis with resulting fibrosis. In a few of the larger bronchi, rare Langhans giant cells were present in the submucosa, but with no granuloma formation.

All sections of the pulmonary parenchyma displayed numerous large and small, discrete and confluent infiltrations which were composed of interlacing epithelioid cells with

*Intubation for operation was easily done, and a proper sized tube was used. Bronchoscopy was performed with minimal trauma. The necessity for a second tracheotomy suggests that some constitutional factor might have produced abnormal tracheobronchial secretions.

†Pathology report by Dr. Alexander A. Kosinski, Charles S. Wilson Memorial Hospital.

numerous scattered multinucleate giant cells of the Langhans type. In many instances, especially in the larger granulomas, centers of caseous necrosis were prominent. Lymph nodes from the hilar area were likewise involved by an identical process.

Subsequent Course.—A two-stage thoracoplasty was completed a few weeks later following which the patient has continued to make excellent progress. All postoperative examinations of the sputum have been negative, and the patient is now doing her own housework. A recent chest roentgenogram is reproduced in Fig. 4.

ETIOLOGY

Fibrinous bronchitis has received comparatively little attention in the recent literature, and a review of the subject has not been published since 1920.[28] Most of the communications have been isolated case reports, many of which are incompletely documented; a large percentage of these publications has appeared in the foreign literature. Both acute and chronic types of the disease have been described; the acute form is comparatively uncommon. The bacteria which have been cultured from the casts include: streptococci, staphlococci, corynebacterium, diphtheria, Klebsiella pneumonia, Myobacterium tuberculosis, and Hemophilus influenza.

A bewildering variety of both thoracic and constitutional diseases has been associated with the formation of bronchial casts. In the pulmonary group are included asthma, influenza, pneumonia, tuberculosis, congestive heart disease, bronchial compression due to any cause, and the inhalation of various noxious agents. The constitutional group includes: measles, typhoid fever, scarlet fever, erysipelas, smallpox, pemphigus, and impetigo.

Walker[28] expressed the view that the expectoration of casts may be either symptomatic or idiopathic. It was his opinion that fibrinous bronchitis actually is a disease entity, but that this diagnosis should not be made if the formation of the casts were related or secondary to another disease. The association of bronchial casts with various bacteria and many unrelated diseases makes it difficult to accept the concept that fibrinous bronchitis actually is a disease entity.

An allergic basis for the disease has been proposed, and this thesis is supported by its association with asthma[5] and increase in eosinophils.[18] Comparison of the disease with mucous colitis has been made.[8, 28] A metabolic disturbance of the bronchi[11] has been proposed. In addition, it has been suggested that the disease is a type of neurosis[28] or that some infectious, chemical, or physiochemical agent is the responsible etiologic factor.[23]

From the above it is seen that a satisfactory explanation for the occurrence of these casts has not yet been advanced. It does seem clear, however, that the acceptance of fibrinous bronchitis as a disease entity is at best a tenuous concept. At this time it appears acceptable to consider these casts as a clinical phenomenon due to an abnormal response of the bronchial glands, and epithelium to a bacterial, thermal, or chemical irritant. Clinically, the formation of bronchial casts appears to occupy a position somewhere between diphtheritic membranes and the bronchial crusts which may form after tracheotomy in

patients having acute tracheobronchitis. In these diseases extensive destruction of epithelium in the former and the drying effect of tracheotomy in the latter appear to be the important etiologic factors.

THE BRONCHIAL CASTS AND ASSOCIATED BRONCHITIS

The physical properties of bronchial casts are fairly uniform. They are white or grayish-white in color, rather firm and rubbery in consistency; they are occasionally blood stained.[6, 19] In typical examples the larger branches are tubular; the smaller branches are usually solid.[6, 8, 19, 28] Microscopic studies demonstrate a mucous or gelatinous matrix with interlacing fibrils of fibrin. The casts commonly contain epithelial cells, red blood cells, leukocytes, and various bacteria. Descriptions of the associated bronchial pathology vary considerably, reflecting the infrequent autopsy and bronchoscopic studies that have been made. Loss of epithelium,[28] breaks in epithelium, and excessive numbers of mucus-secreting cells of the bronchial glands[8] have been described. Callahan[6] reported that bronchoscopy showed his patient to have normal bronchi ten days after the expectoration of casts.

TUBERCULOUS BRONCHITIS

Although this article is concerned with a tuberculous variant of fibrinous bronchitis, it seems appropriate to summarize those features of tuberculous bronchitis which are germane to this discussion. By contrast, tuberculous bronchitis is a common disease; in a recent article 500 cases were reported by a single observer.[15] A voluminous literature on this subject has accumulated since 1931 when Eloesser[10] called attention to the importance of tuberculous bronchial stenosis. It is now well established that tuberculous bronchitis is a common complication in patients having advanced pulmonary tuberculosis. In exceptional instances bronchial disease may follow the rupture of a caseous lymph node into the tracheobronchial tree.[3, 4] Examples of tuberculous bronchitis in patients having little or no pulmonary tuberculosis are comparatively rare.[21, 25] Bronchial infection has been found to be an important unfavorable factor in the prognosis of parenchymal disease, and in addition is commonly a serious deterrent to the benefits of collapse therapy.[1, 7, 27] It has been established that a particularly grave prognosis is occasioned by bronchial stricture associated with post-stenotic pulmonary suppuration, and that the most satisfactory treatment for patients in this category is resection.[9] Contrary to what might be expected, specific reference to the association of fibrinous bronchial casts with tuberculous bronchitis has not been found.

NONTUBERCULOUS FIBRINOUS BRONCHITIS

Fibrinous bronchitis may be acute or chronic. In what appears to be an artificial subdivision, a third invariably fatal type has been mentioned in which casts are not expectorated but are discovered at autopsy.[28] In general, the acute type is one in which the constitutional symptoms are severe, the course of the disease is brief, the illness terminating either in death from asphyxia or recovery without recurrence.

Two recently reported examples of the acute form of the disease are of interest. Johnstone's[14] patient was a 21-year-old student nurse who presented signs of an acute respiratory infection with fever, tachycardia, and increased respiratory rate. Within twenty-four hours she developed extreme expiratory dyspnea, harassing cough, and cyanosis. This episode was terminated by the expectoration of a large bronchial cast. Signs of anoxia recurred and were progressive; eighteen hours later an emergency tracheotomy was done, and additional casts were removed with forceps. The patient died a few hours later; the duration of her illness was less than two days. The second patient[18] was an infant, 20 months old, whose illness also began with signs of acute bronchitis. Dyspnea, cyanosis, and radiological evidence of atelectasis of the right lung developed within five days. At bronchoscopy fibrinous material occluding the right main bronchus was removed with the aspirator and forceps. The patient recovered rapidly and was discharged nine days later. Comparatively few other publications record the occurrence of atelectasis[13, 16, 17, 22, 23] or the bronchoscopic removal of casts.[12, 13]

The chronic form of fibrinous bronchitis is the one most commonly encountered. Examples of this type usually occur in middle life, and the patient generally gives a history of previous attacks of acute bronchitis with chills and fever. Characteristically, the patient has repeated bouts of severe paroxysmal dyspnea and cough which terminate in the expectoration of a bronchial cast. A peculiar inspiratory flapping sound, produced by movement of the partially separated casts, may be heard over the affected lung.[20] This physical sign is repeatedly described in the literature, but is rarely heard.

The casts resemble curdled milk in appearance; they are best seen by immersing them in water; in this way branching to bronchial divisions as small as those of the fifth order may be demonstrated. As many as six casts may be expelled in a single day,[6] and this may continue for weeks or even months. Recovery may be followed by recurrence of the symptoms after an interval of months or years.

TUBERCULOUS FIBRINOUS BRONCHITIS

Information regarding the incidence of fibrinous bronchitis in pulmonary tuberculosis is fragmentary. Norris and Landis[20] did not encounter a single case among the patients seen during a thirteen-year period at the Henry Phipps Institute. In addition, they saw no examples at autopsy among 662 individuals having pulmonary tuberculosis. The same authors, however, found twenty examples in the literature, thirteen of which were discovered at post-mortem examination. Schroder[26] observed five cases among 4,716 tuberculous patients. Auerbach[2] reported one case observed at autopsy in a patient having extensive chronic pulmonary tuberculosis. The evidence supporting a diagnosis of tuberculosis in the patient reported by Perlstein[22] is inconclusive. His patient presented massive atelectasis and immediate improvement followed the expectoration of a bronchial cast. The patient's sputum was negative; the chest

roentgenogram suggested inactive tuberculosis in both upper lobes. One must conclude that fibrinous bronchitis is a rare complication of pulmonary tuberculosis.

DISCUSSION

As previously noted, reference to the association of bronchial casts with tuberculous bronchitis has not been found. It seems likely, nevertheless, that the patient described in this report is an authentic example of tuberculous bronchitis and that this disease initiated the formation of the bronchial casts. The history of tuberculous cervical adenitis and the absence of evidence of parenchymal disease in the admission chest roentgenogram suggests that rupture of a caseous lymph gland into the left bronchus may have initiated the bronchial disease.* The bronchopneumonic lesion in the lower lobe of the left lung appeared immediately following the bronchoscopic procedure and tracheotomy. This sequence suggests that the pulmonary infection was due to partial bronchial obstruction and retained purulent secretions. Similar episodes following diagnostic bronchoscopy occurred in two of the eight patients reported by Ornstein and Epstein.[21] If a diagnosis of tuberculous bronchitis had been established when the tracheotomy was done, streptomycin therapy might have effectually prevented the progress of the disease which eventuated in pneumonectomy.

Considering the length and size of bronchial casts, it is rather surprising that asphyxia or atelectasis has not been more commonly reported. This may be explained in part by the fact previously noted that the larger segments of the casts are hollow, and thus usually fail to cause complete bronchial obstruction. As a consequence, some air can be inspired in the affected lung, the "bechic blast" of the cough mechanism is preserved, and the patient is ordinarily able to expel the cast, although this may be extremely difficult. An explanation is required for the unusual difficulty in expelling casts experienced by patients having the acute form of the disease. This is probably due to an associated severe bronchitis with destruction of bronchial epithelium. Under such circumstances adherent casts and ineffectual cough would be anticipated. Severe inflammation of the bronchial mucous membrane was observed in the patient reported here. The radiological findings are variable[8, 24] and the chest roentgenogram is frequently negative; the occurrence of atelectasis has already been mentioned.

A survey of the literature shows that bronchoscopy has been infrequently utilized in either the diagnosis or management of fibrinous bronchitis. The few reports thus far published and the case described here, show the advantages of a bronchoscopic approach to this problem. In any acute respiratory infection which is complicated by the development of signs of bronchial obstruction and anoxia, the possibility of fibrinous bronchitis should be entertained and bronchoscopy performed. The development of massive atelectasis under these circumstances also points to this diagnosis if the patient's history does not suggest one

*Caseous glands were not observed at operation, but microscopic study demonstrated tuberculosis of the bronchopulmonary glands.

of the conventional causes for this complication. The physical properties of the casts may require their removal under direct vision with forceps. Under such circumstances a tracheotomy might be entirely ineffectual.[14] Recurrence of casts may require tracheotomy, but this procedure should be preceded by their thorough removal by bronchoscopy.

SUMMARY

A patient having bronchial obstruction and alarming anoxia due to acute tuberculous fibrinous bronchitis is reported. Bronchoscopic removal of casts and tracheotomy were required; the patient subsequently developed, in rapid sequence, a bronchial stricture and bronchiectasis. Pneumonectomy was required; the patient recovered. It is emphasized that the occurrence of atelectasis or bronchial obstruction in the course of an acute respiratory infection may be due to fibrinous bronchitis. It is recommended that bronchoscopy should occupy an important place in the diagnosis and treatment of this rare disease which may be rapidly fatal.

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BENIGN THYMOMA IN THE HILUS OF THE LUNG

Case Report

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RECENT reports in the literature[1, 2] have emphasized the importance of early exploratory thoracotomy for intrathoracic tumors which defy clinical identification. With more widespread acceptance of this surgical philosophy, tumors formerly thought to be very uncommon will undoubtedly be seen more frequently. The case history to be presented is at the present time a rarity, although with the increasing number of diagnostic thoracotomies being performed the true incidence of this type of tumor may be established.

CASE REPORT

E. P., a 37-year-old white housewife, was referred on Oct. 13, 1951, for diagnosis and treatment of a mass in the hilus of the left lung. The lesion was discovered on a routine roentgenogram of the chest. There were no complaints referable to the mass, and no history of cough, hemoptysis, or dyspnea could be elicited. No symptoms were present to suggest myasthenia gravis. The patient recalled having had pneumonia in 1946, and roentgen films taken at that time, which were subsequently obtained (Fig. 1, *A*), showed the presence of the hilar mass. It was suggested that additional chest films be taken one month after recovery but, because of the absence of symptoms, the patient did not return.

Physical examination revealed normal vital signs, and no abnormalities were noted on examination of the lungs and heart. Roentgen films taken at the time of hospitalization (Fig. 1, *B*) revealed a homogeneous, clearly defined, smooth-walled oval density in the left lung adjacent to the hilar region. The lateral x-ray projection showed that the mass was superimposed on the other structures of the hilus. When viewed fluoroscopically the mass did not pulsate, and no connection to the esophagus could be demonstrated. It moved only slightly with diaphragmatic excursion.

Bronchoscopic examination revealed no bronchial compression nor other abnormalities. Routine laboratory work included urinalysis, complete blood count, sedimentation rate, and serological studies, all of which were normal.

On the presumptive diagnosis of a bronchiogenic cyst, an exploratory thoracotomy was performed on Nov. 13, 1951. The left pleural cavity was entered through the bed of the fifth rib which was excised subperiosteally. The tumor, measuring 2 by 2.5 by 4.5 cm., was located in the left hilar region at the base of the interlobar septum. It was covered laterally by visceral pleura, and medially was in close proximity to the pulmonary artery. The parenchyma of the upper and lower lobes covered its superior and inferior surfaces. It was salmon pink in color and was easily shelled out by blunt dissection, being attached only by a small hilar blood vessel which was divided and ligated. Exploration of the left thoracic cavity revealed no further abnormality, and no thymic remnant was noted. After an uneventful convalescence the patient was discharged on the tenth postoperative day.

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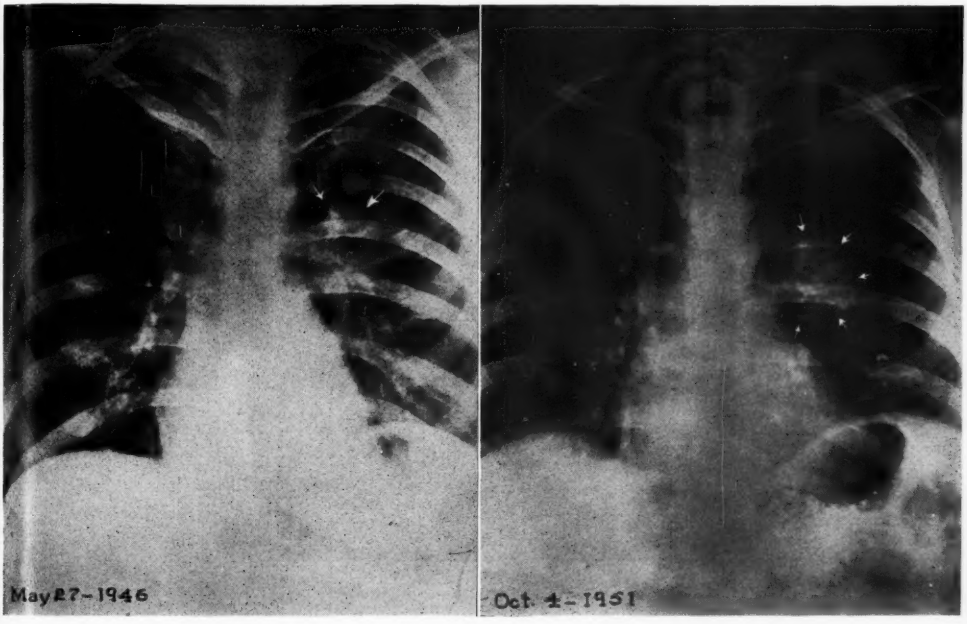
PATHOLOGY

The oval mass, which was well encapsulated, measured 4.5 by 2.5 by 2 cm., and on section revealed a homogeneous fleshy, grayish-pink surface. Microscopically the mass was quite cellular, and showed a well-defined fibrocollagenous capsule. Small lymphocytes (thymocytes) were the predominant cells, and scattered throughout the sections were many Hassel's corpuscles composed of epithelial cells arranged in a concentric fashion. Some of these corpuscles showed central hyalinization. The small lymphocytes were closely aggregated around the corpuscles and formed a follicular arrangement (Fig. 2). No evidence of differentiation into cortex and medulla was noted. Arterioles were seen throughout the section, some of which showed hyalinization of the wall, and subcapsular hemorrhage was also noted. No evidence of invasion or malignant degeneration was noted. A diagnosis of thymoma was made pathologically. However, since the tumor probably arose from an aberrant thymic anlage, it could also be called a thymic choristoma.



A. *B.*

Fig. 1, *A.*—Note the well-circumscribed nature of the left hilar mass.
Fig. 1, *B.*—Roentgen films taken five and one-half years later show essentially no change in the left hilar density.

DISCUSSION

To our knowledge, only one other such case has been reported,[3] the tumor being discovered at autopsy. This lesion caused compression of the bronchus, and apparently contributed to the death of the patient during a routine tonsillectomy.

Embryologically, the existence of thymic tissue in the hilus of the lung is difficult to explain. A brief review of the development of the thymus in the

human being will readily account for the thymic cell rests that have been reported in the thyroid gland, lateral cervical regions, and in association with the parathyroid glands.[4, 5] Arey[6] states that the primordia of the human thymus appear at the end of the sixth week of intrauterine life (12 mm. embryo) as ventral pouches of the third pair of pharyngeal pouches. The origin of the parathyroid glands from the dorsal wings of these same pouches explains the occasional existence of thymic cell rests in the cervical region. Other investigators[7, 8] have reported rudimentary thymic tissue arising from the fourth pharyngeal pouch. These, however, probably do not take part in the formation of the normal thymus gland. The earliest indication of the future respiratory organs is the so-called laryngeal-tracheal groove which appears in 3 mm.

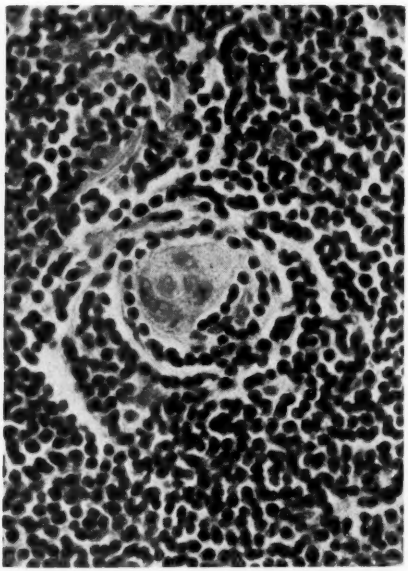


Fig. 2.—This microscopic section shows Hassel's corpuscle with the small thymocytes arranged about it presenting a histologic pattern compatible with the diagnosis of thymoma.

embryos and runs lengthwise in front of the gut just caudad to the fourth pharyngeal pouch. This gives some tenability to Patterson and Heller's[3] theory that the presence of ectopic thymic tissue in the lung could be explained by an abnormal intimate relationship between the rudimentary thymic tissue in the fourth pharyngeal pouch and the tracheal anlage, the former descending with the latter.

The existence of thymic tissue in an adult after regression of the normal thymus gland suggests that this should be considered a true tumor arising from an aberrant cell rest. If this were not a neoplasm, one would expect the same factors to act upon it as were in effect on the thymus in its normal location.

The presence of this tumor in a 37-year-old woman without grossly demonstrable persistent thymic tissue and its lack of differentiation into cortex and medulla would favor the diagnosis of thymoma instead of an aberrant cell rest.

SUMMARY

An unusual case of a thymic tumor arising in the hilar region of the lung at the base of the left interlobar septum is presented. To our knowledge, this is the second such case to be reported, although it is our feeling that more tumors of this type may be discovered as the number of survey chest films and subsequent thoracotomies increases.

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Announcement

THE AMERICAN ASSOCIATION FOR THORACIC SURGERY

Notice of Annual Meeting

The 33rd annual meeting of the American Association for Thoracic Surgery will be held March 27, 28, and 30, 1953, in San Francisco, Calif. Headquarters will be at the Hotel Fairmont. Suitable accommodations also have been reserved at near-by hotels, the Mark Hopkins, the Huntington and the Sir Francis Drake.

Requests for Hotel Reservations

These should be mailed to Dr. H. Brodie Stephens, Chairman of Hotel Committee, American Association for Thoracic Surgery, Room 200, 61 Grove St., San Francisco 2, Calif. The following information must be included: (1) two choices of hotels; (2) type of accommodation desired—single, double, twin, room or suite; (3) name of other room occupants, if any, whether wife or another doctor; (4) date and approximate hour of arrival; (5) date of departure; (6) return address.

Abstracts for Papers

Abstracts for the presentation of papers at the 1953 meeting must be received on or before Dec. 1, 1952, otherwise they will not be considered by the Program Committee. *Five, repeat, five* copies of each abstract should be sent to the Secretary of the Association, Dr. Paul C. Samson, 2938 McClure St., Oakland 9, Calif. They should not be sent to the Editor.

The abstracts should contain from 200 to 250 words, and should accurately reflect the contents of the completed paper.

Applications for Membership

Applications for Associate Membership in the American Association for Thoracic Surgery must be received by the Membership Committee not later than December 1, 1952, to be considered for action at the meeting in San Francisco in March, 1953. Applications received on a date beyond that deadline must be deferred for consideration until 1954.

Applicants must be sponsored by three Active or Senior Members of the Association. In addition to the sponsoring statement on the application form, the sponsors must submit a separate letter concerning the applicant direct to the Chairman of the Membership Committee. These regulations are at the direction of the Council and were made effective at the meeting in Dallas in 1952.

Completed application forms should be sent to the Chairman of the Membership Committee, Edward M. Kent, M.D., 1406 Clark Building, Pittsburgh 22, Pa.